

Source Water Protection Planning in Metropolitan Canada: Barriers and Opportunities

A Thesis Submitted to the College of Graduate
Studies and Research in Partial Fulfillment of the
Requirements for the degree of Master of Arts in
the Department of Geography and Planning
University of Saskatchewan
Saskatoon, Saskatchewan

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ABSTRACT

Source Water Protection (SWP) is recognized as the first barrier in the multi-barrier approach to reduce the risk of drinking water contamination. In Canada, provincial water agencies and municipalities lead most of the water management responsibility based on provincial regulations. However, SWP planning and implementation is variable across jurisdictions and influenced by different factors related to local capacity. Much of the water resources literature is focused on capacity-building limitations faced by small and rural water system operators. The purpose of this research is to investigate capacity-building limitations faced by metropolitan water system operators. Information from a questionnaire and document review in four selected Canadian metropolitan areas was gathered and analysed in this study. The results of this study show variability of SWP planning uptake as well as variability in approach toward SWP implementation. While large metropolitan areas may appear to possess ready access to financial capital, technical capability, and other forms of capacity to undertake SWP, the results of this research indicate the opposite. Metropolitan areas in Canada remain reliant on advanced water treatment and other engineering solutions to provide safe drinking water as opposed to SWP planning that invests in preventative measures through land use planning mechanisms. The results of this research contribute to the knowledge and understanding of SWP particularly as applied to metropolitan Canada.

ACKNOWLEDGEMENTS

I am grateful to my supervisor, Dr. Robert Patrick for his guidance, encouragement, patience and finding time to reply to my e-mails. He added considerably to my graduate research. It was a pleasure working with him.

I would also like to thank my committee members, Dr. Alec Aitken and Dr. Paul Hackett for providing indispensable advice, information and support on different aspect of my research.

I give my sincere thanks to everyone who participated and shared their knowledge in this research. I would like to acknowledge the Saudi Arabia Culture Bureau for providing me with financial support throughout my research.

Finally, I would also like to thank my family for the support they provided me through my entire life and in particular, I must acknowledgment my great mother Maryam, my dear husband Zaki, and my two kids whom shared my journey in Canada, Sara and Hassan - without whose love, I would not have finished my research.

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LIST OF ABBREVIATIONS

BSLB	Brown Spruce Longhorn Beetle
CCME	Canadian Council of Ministers of the Environment
CRD	Capital Regional District
CTC	Credit Valley, Toronto and Region and Central Lake Ontario
CWA	Clean Water Act
GVWSS	Greater Victoria Water Supply System
HR	Human Resources
MBA	Multi- Barrier Approach
OMOE	Ontario Ministry of the Environment
RMOW	Regional Municipality of Waterloo
RWMP	Regional Watershed Monitoring Program
SDWA	Safe Drinking Water Act
SSRWSI	South Saskatchewan River Watershed Stewards Inc.
SWA	Saskatchewan Watershed Authority
SWP	Source Water Protection
TRCA	Toronto Region Conservation Authority
TRSPA	Toronto Region Source Protection Area
USEPA	United States Environmental Protection Agency
WHO	World Health Organization
WSA	Water Security Agency

CHAPTER 1

1.0 INTRODUCTION

Safe drinking water is a basic human need necessary to ensure health and well-being. Yet, water contamination is a serious global issue. In developing countries, millions of people die every year because of contaminated drinking water (Hrudey et al., 2006). It is estimated that 90,000 illness and deaths occur globally every day due to contaminated drinking water (Christensen, 2006). In developed countries, water contamination incidents have occurred in the last few decades. For instance, at Walkerton, Ontario, the drinking water supply was contaminated by *E. coli* O157: H7 and *Campylobacter*, and caused seven deaths and 2,300 illnesses. After the Walkerton tragedy the Ontario government designed under the Public Inquires Act a special Commission with the goal to analysis the causes of the contamination and design recommendations to protect municipal drinking water systems across the province (Lindgren, 2003). The Walkerton Inquiry described a number of failures that caused the outbreak such as lack of training and experts to identify the vulnerability of the well water source. Furthermore, the Walkerton Inquiry described the failure of many regulations of the Ontario government to protect drinking water supplies as a contribution factor of the tragedy. For example, the budget reduction at the province's Environment Ministry reduced the capability to identify the issues at Walkerton's water utility (O'Connor, 2002). Thus, provincial government initiatives and regulations should be designed and put in place to protect municipal drinking water quality. The second part of the Walkerton Inquiry (O'Connor, 2002), identified the importance of Source Water Protection (SWP) as a critical stage in drinking water protection. SWP is the first barrier in the multi-barrier approach to preventing drinking water contamination. The multi-barrier approach is defined as "an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from

source to tap in order to reduce risks to public health” (Canadian Council of Ministers of the Environment and Federal-Provincial-Territorial Committee on Environmental and Occupational Health [CCME], 2002).

The concept of SWP was codified in the United States in 1996 in the amendments to the Safe Drinking Water Act (USEPA, 2002). SWP is defined as any practice aimed at reducing either contamination or the potential for contamination at the water source. SWP includes structural and non-structural management actions by water providers, stakeholders, and managers, aimed at preventing contamination at the source. Examples of structural management actions include simple fencing and off-watering sites to prevent animal grazing near the source of a water supply (Kendall, 2001) and the restriction of cattle movement adjacent to rivers and streams (Patrick, 2005). From an economic point of view SWP is less expensive than remediation of a contaminated water source (Parkes et al., 2010; Timmer et al., 2007). However, Canada has no overarching federal source water protection legislation. SWP guidance from the federal government has only recently been made available, and only for on-reserve First Nation SWP planning (Patrick, 2014). In Canada, provincial governments have authority to legislate SWP policies and practices, including legislation. A variety of SWP legislation and policy currently exists across the provinces and territories of Canada, but without consistency across jurisdictions (Patrick et al., 2013). To date, most SWP research in Canada focuses on rural and small system water supplies with attention to local capacity needs to support SWP planning. The focus of much of the early work in this field is on capacity limitations and capacity-building needs of rural and small system water operators. The rationale for this research is to investigate the capacity limitations and capacity-building needs of metropolitan areas to support SWP planning. A metropolitan areas, sometimes referred to as a “metro area” or “metro”, is herein defined as “a region consisting of a densely populated urban

core and its less-populated surrounding territories, sharing industry, infrastructure, and housing” (Squires, 2002).

1.1 Research Goal and Objectives

The goal of this research is to identify the opportunities and challenges in developing SWP plans for metropolitan areas in Canada. To achieve this goal, there are three main objectives.

1. To identify capacity-building factors that facilitate SWP in metropolitan areas.
2. To identify capacity factors that constrain SWP in metropolitan areas.
3. To derive lessons learned for advancement of SWP planning in metropolitan areas.

In the aftermath of the Walkerton contamination event in May 2000, research into SWP has been conducted in mostly rural areas of Canada to identify factors that facilitate and constrain implementation of SWP plans. For instance, de Loë et al. (2002) conducted studies in three small Ontario communities to analyse the factors that shape local capacity for groundwater protection. A similar study analysing the factors that influence local capacity to protect groundwater resources in agricultural communities in Ontario was conducted by de Loë and Kreutzwiser (2005). Ivey et al. (2006a) evaluated the extent to which existing institutional arrangements for land use planning and water management enhance or constrain the capacity of local governments in Alberta to protect source water in the Oldman River basin. Moreover, Timmer et al. (2007) conducted a study in rural Nova Scotia to identify the factors that facilitate the building of local capacity for SWP in small communities in the Annapolis Valley. In the area of agriculture, Patrick et al. (2008) evaluated the factors that facilitate and constrain SWP in four case studies in the Okanagan Valley, B.C. all these cases exemplify SWP research concentrated on rural and small

water systems. This existing research remains valid given past experiences with drinking water contamination in rural settings where local capacity is restricted by virtue of limited resources and capacity restrictions related to community size.

There is little in the current literature describing factors that facilitate or constrain the practice of SWP in metropolitan Canada. This research will fill that gap by adding new knowledge to the literature, adding new information by shifting attention from rural areas with small populations to metropolitan areas with large populations.

CHAPTER 2

2.0 LITERATURE REVIEW

A review of the water resources literature pertinent to SWP will be addressed in this chapter. Specific areas of focus include the multi-barriers approach, SWP and capacity for action.

2.1 The Multi-Barrier Approach and Source Water Protection Plans

The multi-barrier approach has been presented as a reliable strategy to ensure safe, clean drinking water. The multi-barrier approach is defined as “an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health” (CCME, 2002). The approach has five integrated components that work as a system of redundancies to safeguard drinking water for human health: (a) SWP program, (b) treatment plant, (c) water distribution system, (d) monitoring of water quality, and (e) an emergency response program for adverse test results. This integration is important to emphasize the link between water quality at the source, drinking water quality, and the human health benefits of the multi-barrier approach (CCME, 2002). In this research, the focus will be on the first barrier, SWP, and its role in preventing contamination and providing safe drinking water in Canadian metropolitan areas.

Safe, clean sources of drinking water are a global issue in both developing and developed countries. Studies have shown that there is a direct relationship between surface and groundwater quality and human health (Davies & Mazumder, 2003; Fremaux et al., 2009). The 1996 amendment to the Safe Drinking Water Act (SDWA) recognized specific components to reduce and prevent the adverse effects of cumulative hazards to water resource (United States

Environmental Protection Agency [USEPA], 2002). The American Water Works Association Research Foundation defines SWP as any “program [including] actions, policies, and practices to protect and enhance the source of drinking water” (AWWARF, 1991). Source water protection is a planning practice that aims to prevent water contamination at the source of supply. The main objective of SWP is to minimize the potential for waterborne hazards to contaminate water resources. SWP includes making and implementing plans to reduce the risk of surface or groundwater contamination. For surface water, SWP takes the form of managing the watershed or catchment, while protection of groundwater concerns itself with safeguarding private wells and local water fields and with the recharge of groundwater zones and aquifers (Natural Research Council, 2000). The practice of SWP entails four procedures: mapping of the water supply source area, identification of any risk to water quality, determination of susceptibility of water contamination, and development of management strategies (Patrick, 2005). These procedures are vital to protecting drinking water quality and preventing waterborne contamination.

2.2 Need for a Source Water Protection Plan

2.2.1 Source Water Protection and Human Health

Adequate drinking water quality has a direct relationship to human health and well-being, and vice versa; deterioration of water quality is the cause for the spread of many water-borne diseases—here defined as “any illnesses caused by drinking contaminated water. The contamination can be by bacteria such as *Salmonella* or *Campylobacter*, viruses, or small parasites including *Cryptosporidium*, *Giardia*, and on rare occasions *Toxoplasma*” (British Columbia Ministry of Health, 2006). According to the United Nations’ sustainable development plan published as “Agenda 21” (1993), the consumption of contaminated water causes almost 80% of the total instances of disease in developing nations, and results in one third of total deaths. In 1997,

the World Health Organization (WHO) determined that ensuring availability of clean drinking water is a basic goal for human species. The WHO estimates indicate that about 50% of the population in developing nations will be infected with a potentially fatal microbial illness related to source water and sanitation. Moreover, each year more than three million children under 5 years of age will die of diarrheal illnesses (WHO, 1997). In 2003, the Third World Water Forum announced that more than five million people die each year from water-borne diseases worldwide. Several studies have been conducted to identify the relationship between water quality and human health. In order to understand the best safeguards against these pathogens, Yassi et al. (2001) have classified water-borne diseases according to the various environmental phenomena and human activities that can cause the spread these diseases. Davies and Mazumder (2003) have found that many of the pathogens and natural processes that affect water quality can be limited through SWP. It is worth mentioning that pathogens in drinking water can be fatal and may lead to the outbreak of acute diseases. A literature review conducted by Patrick (2005) on the connection between microbial infection and SWP in British Columbia explained how pathogenic bacteria, viral agents, and parasites may contaminate public drinking water supplies. In each type of contamination, it was found that SWP measures were the key to reducing pathogens and enhancing the quality of source water (Patrick, 2005).

Developing a SWP plan is the most effective strategy to eliminating the distribution of many microbial illnesses because most hazardous microbial organisms with the potential to contaminate water are resistant to water treatment operations. For example, studies have found that *Cryptosporidium* and *Giardia*'s oocysts and cysts can remain active even after chlorination and must be removed by costly filtration procedures (Davies & Mazumder, 2003). A study by LeChevallier et al. (1991), conducted on several sources of water, found the lowest concentrations

of both *Giardia* and *Cryptosporidium* at fully protected water supplies where access to the watersheds was strictly limited. In addition, implementing successful SWP plans to remove hazardous pathogens involves hiring specialists to conduct comprehensive tests of the water source and enforcing recommended standards to limit hazards (SWA, 2007). Thus, providing clean drinking water by preventing contamination at the source is the most effective way to ensure human health (Pollution Probe, 2004).

2.2.2 Source Water Protection and Economic Benefits

SWP has economic benefits that make it the first barrier of a multi-barrier approach (CCME, 2004). In 1995, the U.S. Environmental Protection Agency's (USEPA) Ground Water Protection Division reported the benefits and costs of protecting water sources (Job, 1996). In this economic analysis of SWP, it was found that remediation of a contaminated water supply is much more costly than protecting the same supply. Moreover, Job (1996) showed that the ratio of pollution-remediation to protection program is more than 200:1, and the cost of remediating groundwater is 40 times more expensive than developing a SWP plan for a groundwater supply. According to Pollution Probe (2004), SWP has both direct economic benefits, such as diminishing costs associated with remediating lost habitat sites and establishing treatment systems, and indirect cost savings such as the expense to the public health system of treating people that have water-borne diseases. Moreover, the United States Environmental Protection Agency (USEPA, 2000) declared that hundreds of millions of dollars could be saved each year by protecting drinking water supplies. The high cost of water treatment plant operations could also be reduced by practicing SWP. To provide high-quality drinking water and limit future costs of filtration, New York City has developed a watershed management plan with the goal of protecting its water source (Chichilnisky & Heal, 1998; Foran et al., 2000).

2.3 Facilitating and Constraining Factors

Source water protection, as defined by Patrick et al. (2008), is characterized by watershed and aquifer management for the protection of drinking water. The procedures and tools to implement a SWP plan vary based on the size of the water supply, land use activities in the area, and the type and level of risk. SWP plans include both regulatory tools, such as legislation and bylaws, and non-regulatory tools such as stewardship and education programs (Simms et al., 2010). According to the Saskatchewan Watershed Authority (2007), SWP is targeted at protecting specific ecosystems such as wetlands that remove contaminants and purify our drinking water; protecting water for recreational uses such as swimming and boating; and maintaining water supplies for livestock use, and for the protection of wildlife and fish habitats.

Effective SWP plans do not necessarily share specific techniques or approaches; SWP can be achieved using different methods: “SWP can be achieved in many ways, and the choices made in specific regions or watersheds about the balance of regulatory and non-regulatory tools should reflect local needs, issues, and capacities” (Simms et al., 2010). In an amendment to the SDWA (1996), six procedures were outlined for preserving source water programs and providing safe drinking water for public water systems: delineating the drinking water source protection area, inventorying sources of contamination, determining the susceptibility of the water supply system to contamination, getting the public involved, implementing management measures, and developing a planning strategy (USEPA, 2002).

To facilitate the inventory of potential risk to local water supplies and provide recommendations for short- and long-term planning of SWP implementation and best management

practices, source water protection involves communication between multiple stakeholders (CCME, 2002). Fischer (2000) considered public and community involvement critical to effective planning by making it easier to identify and mitigate local issues. Forming a SWP committee is a fundamental and effective step to soliciting input and consultation from stakeholders. The committee consists of an integrated team working collectively to develop a plan. The committee should include representatives from all affected groups from federal, provincial, and municipal stakeholders to ensure that all source water issues are addressed in the early steps of SWP (Nova Scotia Environment, 2009). Consultation from scientists and experts (such as hydrologists) is important to solving technical issues for SWP; Moran and Wood (2009) stated that scientific involvement in the evaluation, analysis, and recommendation phases of the SWP process has been important to developing a successful watershed management plan for New York City.

Across Canada, there is no consistent federal framework for water management or SWP implementation or regulations. Provincial governments and local municipalities have responsibility for SWP and may have regulations key to protecting water resources (Ivey et al., 2006b). Many factors—political, institutional, and technical, among others—shape the local capacity to practice SWP. The concept and dimensions of SWP capacity in non-metropolitan Canadian areas will be explained in the next section.

2.4 Capacity of Source Water Protection in Non-Metro Canadian Areas

Based on the existing literature related to the factors that facilitate and constrain practicing SWP in several rural Canadian regions, multiple facilitating and constraining factors exist. They include political, financial, institutional, social, and technical factors, all capable of affecting SWP planning strategy (de Loë et al., 2002; Ivey et al., 2002; Litke & Day 1998; Peckenham et al.,

2005). Patrick et al. (2013) stated that factors constraining SWP tend to be institutional and organizational, rather than scientific and technical.

Political factors are the most common issues that constrain SWP in non-metropolitan Canada because no specific water management agency has leadership in this area. Multiple agencies and their shared and overlapped responsibility for SWP are significant barriers that constrain the practice of SWP. For example, in the Okanagan Valley, BC, Patrick et al. (2008) found that the absence of a single leadership agency for SWP and the unclear responsibility for protecting water sources among multiple governments and overlapping agencies at the provincial and local levels combine to serve as a barrier to SWP. Timmer et al. (2007) found a need for leadership from local governments and local citizens for SWP in Atlantic Canada. On a provincial scale, the lack of a clear lead agency to protect drinking water has been an issue for some time (Christensen, 2003; Drinking Water Review Panel, 2002; Morfitt, 1999). Another critical political factor is the lack of legal authority to require SWP plans and control of land use activities for the purpose of controlling and limiting potential contamination of water sources. Clearly, legal authority is needed to control potential contamination of surface water from land- and water-use activities and of groundwater in the local watershed (Balco, 1992; Canter & Mullen, 2002; Peckenham et al., 2002).

Lack of funding, especially in small, rural towns, is another factor that affects the ability to practice SWP and water management generally. Both Leach and Pelkey (2001) and de Loë and Kreutzwiser (2005) stated that the short-term funding of programs to protect ground water resources in small communities often fails to address financial issues related to long-term monitoring and integration of land use and water management. Moreover, based on an analysis of 37 studies of watershed management, Leach and Pelkey (2001) concluded that the most common

factor necessary for watershed management is adequate funding. Timmer et al. (2007) concurred that appropriate financial capacity for SWP, with increased water rates to finance SWP, is needed to improve SWP in the Annapolis Valley, Nova Scotia.

SWP must be integrated with regulatory agencies in an orderly fashion. There must be clear communication practices and a cooperative structure among all the regulatory agencies, water purveyors, and constituencies who use water for purposes such as agriculture, recreation, and cattle grazing. These bodies must share responsibility while local governments have a responsibility to communicate with these bodies and members of the community (McGuire et al., 1994; Durley et al., 2003). Lack of communication between provincial and local government in decision-making and designing of SWP regulations is considered one of the most vital issues for SWP planning in rural areas (Patrick et al., 2008; Timmer et al., 2007). Timmer et al. (2007) stated, “senior government must pay attention to the needs and capabilities of local government when designing institutional arrangements that are meant to be implemented at the local level”. Communication with other watershed partners, such as industrial partnerships, was the main factor that facilitated the success of SWP in the Okanagan Valley (Patrick et al., 2008), and social support was a strong factor in strengthening the ability of the Regional Municipality of Waterloo (RMOW) to take on the challenge of SWP in Ontario (Ivey et al., 2006b).

On both the provincial and local scales, those practicing SWP planning must have technical knowledge about source water quality, the human health effects of contamination, and water quality risks to the watershed. Limited local technical knowledge of water resources constrained the effectiveness of the SWP plan in the Oldman River Basin of Alberta, for example (Ivey et al., 2006a). For technical knowledge, SWP planning committees may draw upon the skills and knowledge of local residents or engage specialized staff to facilitate the process. SWP plans are

constrained in small communities according to the availability of local expertise and the need for external support. External expertise, either from senior government agencies or local government organizations, is the main source of technical support (de Loë & Kreutzwiser, 2005).

In Canada, provincial governments are responsible for source water legislation. There is no established plan or framework to specify the tools and rules for SWP planning (Pontius, 1996; Trax, 1999). After the Walkerton incident, de Loë et al. (2002) concluded that local governments and agencies have the major responsibility for protecting groundwater resources; because provincial governments have largely ceded their authority on the matter. Therefore, the local capacity for protecting drinking water sources varies based on several factors. The concept of capacity has increased internationally in the water field since the early 1990s (de Loë & Kreutzwiser, 2005). The US SDWA defines capacity as “the ability to plan for, achieve, and maintain compliance with applicable drinking water standards” (USEPA, 1998). Ivey et al. (2006a) described capacity as “conceptualized from a *functional* perspective that focuses on the ability of individuals, organizations, communities, and governments to perform efficiently, effectively and on an ongoing basis, a set of externally defined goals”. The general capacity for SWP is a complex, multifactor state (Timmer et al., 2007). Local capacity to protect drinking water supplies is characterized by the ability of local agencies, organizations, governments, and civil authorities to protect local drinking water supplies. Local capacity can be defined as the factors that enhance or constrain the ability to practice SWP.

Different views are expressed in the literature around the key elements and dimensions that shape local capacity to protect water sources. For example, according to Grindle and Hilderbrand (1995), economic, political, and institutional arrangements are the factors that should be used to evaluate the capacity of public sector agencies, while the USEPA (1998) considered the technical,

administrative, and economic factors to be essential for evaluating the capacity of water management to meet SDWA measures. Timmer et al. (2007) conducted a study evaluating the capacity for SWP of a small community in the Annapolis Valley of Nova Scotia based on social, technical, institutional, financial, and human resource factors.

Furthermore, Ivey et al. (2006a) state that institutional arrangements for land use planning and water resource management are key to shape SWP capacity-building. Institutional arrangements were the factors used to evaluate the local capacity to facilitate SWP at the Oldman River Basin in the Alberta study by Ivey et al. (2006b); these same factors were examined insofar as they facilitated or constrained the local capacity for SWP by the municipality of Waterloo in Ontario (Ivey et al., 2006b).

2.5 Categories of Capacity

This research into the factors that facilitate and constrain SWP in Canadian metro areas will be based on five categories: financial capacity, political capacity, institutional arrangement, technical capacity, and human capacity. The definitions of each category will shape this research and are outlined below.

Financial capacity is the measure of economic flexibility encompassing the local government's ability to adapt to changing circumstances and to provide adequate funding to promote the process of SWP (Mead, 1986). Since financial capacity is one of the most vital elements to facilitate SWP planning, a shortfall in this area is a common reason given for reducing the ability of agencies, institutions, and communities to achieve sufficient watershed management (Litke & Day, 1998).

Political capacity refers to the ability of local government to protect drinking water supplies and create, enforce, and promote policies, legislation, and laws for SWP. The existing local

authority affects current and future land use and management planning in both metropolitan and non-metropolitan areas (Balco, 1992; Canter and Mullen, 2002; Peckenham et al., 2002). A study by de Loë et al. (2002) concluded that horizontal and vertical political linkages with external organizations, agencies, and municipalities are critical for groundwater protection in rural and small communities.

Institutional arrangements involve the existing legislation and regulations, policies and guidelines, administrative structures, economic and financial organizations, and structures that affect the political process (Bandaragoda, 2000; Mitchell, 1989; Mitchell & Pigram, 1989).

Technical capacity, as defined by de Loë et al. (2002), refers to the ability to perform technical activities including resource identification, assessment and limitation of risk, water quality and quantity monitoring, management of data, planning activities, response to emergency, and remediation activities.

Human capacity refers to the role of individual abilities, skills, and knowledge in SWP (Mead, 1986; Merrey et al., 1995) and to the ways in which public awareness and education affect the communication aspect of the public's participation in the processes of facilitating SWP and identifying risk to source waters.

2.6 Summary

The literature reviewed above shows that SWP is a promising approach to limiting the potential for contamination of source water. Protection of drinking water at the source is the first barrier of the multi-barrier approach to providing high-quality drinking water to protect human health by limiting the spread of acute water-borne diseases that cause human death in both developing and developed nations.

However, there is a gap in the academic literature regarding SWP in Canadian metropolitan areas compared to non-metropolitan areas. SWP can be facilitated and constrained based on different factors. These factors vary among different Canadian regions and can be influenced by different levels of local capacity, regulations, and implementation. The contribution of this research is specific to factors that facilitate or constrain of the practice of SWP in Canadian metropolitan areas. In addition, it will derive lessons to enhance SWP literature and the attendant knowledge base focused on Canadian metropolitan areas.

CHAPTER 3

3.0 RESEARCH METHODS

The goal of this research is to investigate the challenges and opportunities of implementing a SWP plan in a Canadian metropolitan area. For this purpose, the study looks at four cities from different regions of Canada: Victoria, British Columbia; Saskatoon, Saskatchewan; Halifax, Nova Scotia; and Toronto, Ontario. These four cities were chosen because each has a different approach to drinking water protection. In addition, the four case studies represent distinct regions of Canada, making this a pan-Canadian study. This study offers the opportunity to examine SWP in various Canadian metropolitan areas to explore whether SWP is location specific and whether one SWP model is more effective than another. In Halifax, for example, a SWP plan, managed locally by Halifax Water, has been in place since 2009 under the requirements of provincial law in Nova Scotia. This provincial law requires SWP plans to be developed at the municipal level across Nova Scotia. By contrast, in Saskatoon the South Saskatchewan River Source Water Protection Plan is administered at the watershed level despite the critical social and economic importance of the river for the local population. In Victoria, the local municipal water department owns almost 90% of the watershed of the drinking water supply, putting that city in a unique position of controlling land use in its water supply. Studying Victoria can help show how the acquisition of direct land title might enhance or constrain the development of a SWP plan for a metropolitan area. Finally, in Toronto, the largest city in Canada by population is considering a proposal to develop a SWP plan at the local level under the authority of the Credit Valley, Toronto and Region, and Central Ontario Lake Source Protection Region (CTC). In all case studies, there is considerable variation in the regulatory framework and institutional arrangements for drinking water protection. This variation will enhance the breath, depth and validity of this study.

What follows is a description of the research methodology for this study.

3.1 Case Study Areas

Four cities from different Canadian regions were selected for this research. These cities are Victoria, British Columbia; Saskatoon, Saskatchewan; Halifax, Nova Scotia; and Toronto, Ontario. Each city can be taken as representative of the respective provincial legislation including SWP planning frameworks.

In Ontario, for example, SWP plans are watershed-based and mandatory for all communities under the requirements of the 2006 Clean Water Act (CWA). Each SWP municipal committee is required to develop a regional risk assessment report and to design a SWP plan. The provincial regulatory measures mandated under the CWA are used to control and restrict local activities that present a hazard to water quality. The assessment report and the SWP plan must then be submitted to the Ministry of Environment (Simms et al., 2010). In British Columbia, all public drinking water systems must comply with the BC Drinking Water Protection Act and BC Drinking Water Protection Regulation (CRD, 2014). However, local utilities, authorities, or water agencies have significant responsibility to conduct and apply SWP activities under the provincial requirement and regulations. Thus, local capabilities and capacities determine the effectiveness of SWP in each respective city. In Toronto, for example, the Toronto Region Conservation Authority (TRCA) under the Clean Water Act is responsible for providing staff and other experts and for facilitating communication and cooperation among local communities and stakeholders to prepare Assessment Reports and Source Protection Plans (CTC, 2014). In Saskatoon, the provincial Water Security Agency holds responsibility for implementing SWP planning, managing the water supply, and protecting the quality of drinking water in cooperation with the City of Saskatoon. In Halifax, the capital of Nova Scotia, it is the commitment of the local Halifax Water Utility, following

provincial legislation that oversees SWP planning. This research will analyse the factors that facilitate and constrain the development of selected metropolitan SWP plans based on local capacity and in consideration of provincial regulations and requirements.

3.1.1 City of Victoria

Drinking water for Greater Victoria comes from a protected watershed called the Greater Victoria Water Supply System (GVWSS). The Sooke Reservoir is the largest supply of drinking water for Greater Victoria, and it is the primary water source for the city supplying approximately 98% of Greater Victoria's drinking water (CRD, 2013). The Sooke Reservoir, located in Sooke Hill to the west of Victoria, serves Greater Victoria. The reservoir, like much of the land in the source water area, is owned and managed by the Capital Regional District (CRD) region, a local government department which is part of BC Provincial Government's initiative. The CRD was created in 1996 in order to cooperate municipal government services and supports regional decision-making and local design- making in rural areas (CRD, 2015a). The CRD is governed by a Board of Directors and have authority from Letters Patent, through design Bylaws which is usually from provincial legislation (CRD, 2015b). The CRD is responsible for over 200 local, regional and sub-regional services for residents of the region, including 13 municipalities and three electoral areas on southern Vancouver Island and the Gulf Islands. The region owns, manages local water system and provides potable water for residential, commercial, institutional, and agricultural uses, serving a total population of about 340,000 people on the southeast corner of Vancouver Island, British Columbia, which is about 98% of existing water supply catchment lands and 92% of future water supply (CRD, 2012).

The CRD aims to protect the municipal drinking quality system and control all sources of risk to water quality, and comply with provincial government regulations and requirements. Forest fires in the Greater Victoria Water Supply Area are a significant risk to water quality. A large-scale fire has an opportunity to increase the adverse effects at water quality such as increasing the amount of surface erosion and nutrients entering the reservoir. Also, the erosion and movement of sediments is another significant factor of risk to raw water quality. Sediment, dissolved minerals, and organic material eroded from the land surface, or from stream channels, entering streams may be carried to the reservoir or into a water intake where they elevate the turbidity and impair colour of the raw water. Additionally, waterborne pathogens in surface water supplies might include parasites, viruses, bacteria, and protozoan pathogens such as *Giardia* and *Cryptosporidium* which cause diarrhea, gastro-intestinal problems, and numerous public human health issues. The pathogens pose a risk to contamination of the regional surface water supply (CRD, 2015).

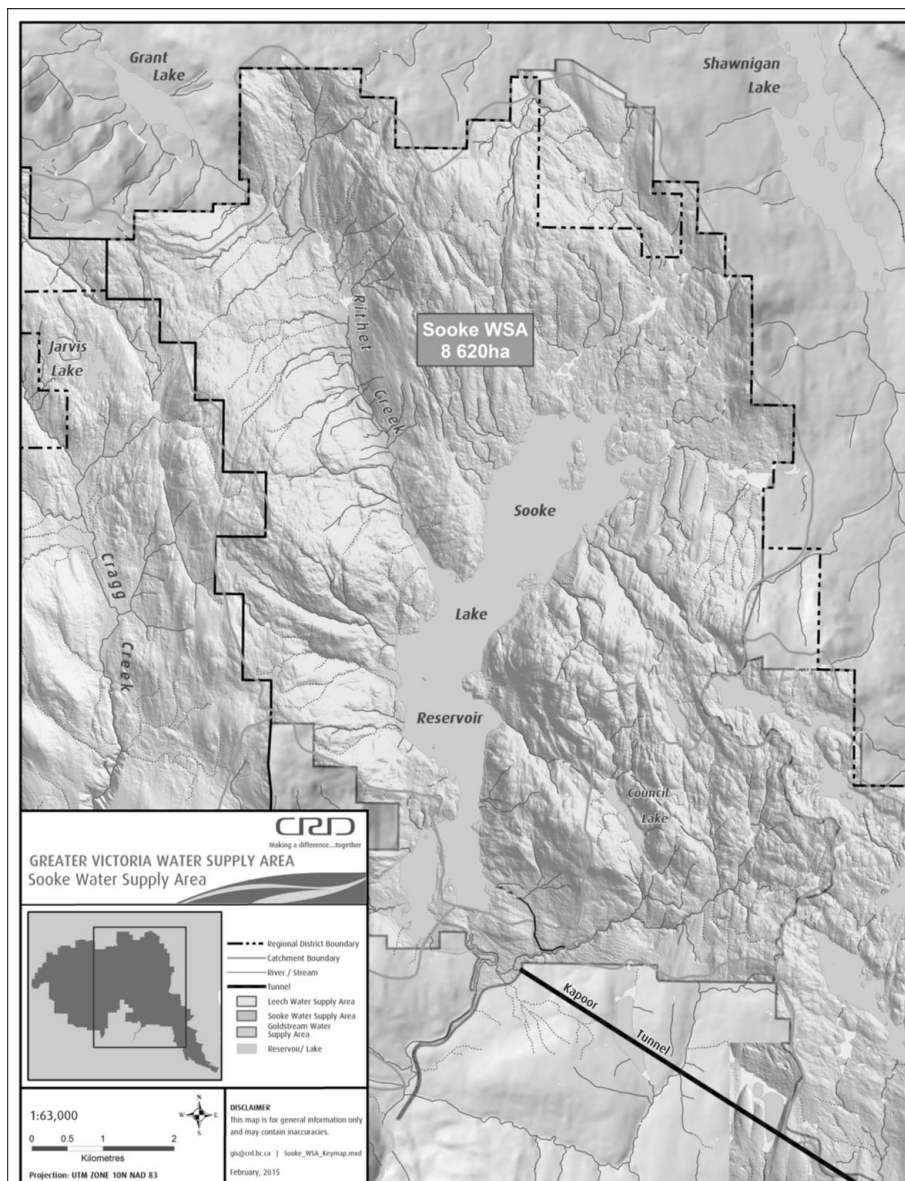


Figure 1: Greater Victoria Water Supply Area: Sooke Water Supply Area Adapted from:
http://www.crd.bc.ca/docs/default-source/water_pdf/map_sookewatersupplyarea.pdf?sfvrsn=0
 (Last accessed on June 17, 2015).

3.1.2 City of Saskatoon

The City of Saskatoon, Saskatchewan, utilizes the South Saskatchewan River as its main source of drinking water. The South Saskatchewan River receives runoff from a land area covering 120,000 square kilometers. The total length of the South Saskatchewan River is about 716 kilometers; in Saskatchewan, the total drainage is 35,000 square kilometers.

The South Saskatchewan River offers the opportunity for a variety of human activities along the river, bringing economic and social benefits. The South Saskatchewan River is the largest source of water for Saskatchewan's population, in addition to supplying about half of the Saskatchewan population with potable water; the river is also used for irrigation, industrial needs, and recreation (SSRWSI, 2014). However, these uses of water have potential adverse effects on the natural water quality through contaminated runoff, increased concentrations of dissolved oxygen and nutrients such as nitrogen and phosphate, and changing water temperatures.

The responsibility for programs related to municipal drinking water, wastewater management, and the protection of surface and ground water were transferred from the Ministry of Environment to the new Water Security Agency (WSA, 2013). Water Security Agency, which is formerly Saskatchewan Watershed Authority (SWA), has the authority to manage watershed, designing partnerships and conducting watershed projects to ensure the safety of watershed quality, such as monitoring and assessments programs to protect and maintain water quality. SWA through a partnership with the South Saskatchewan River Watershed Stewards Inc (SSRWSI) is “[a] grassroots, community driven, and non-profit organization working within the watershed to implement programs and initiatives that will protect the water resource” and supports the fund for the cost of the SWP plan implementations (SSRWSI, 2015). In 2012, the Government of Saskatchewan developed a 25-Year Saskatchewan Water Security Plan to protect and manage

source water quality (SWA, 2012). The Water Security Agency was created in 2012 to bring multiple provincial responsibilities for water together for effective management, and it is tasked with leading implementation of the 25-Year Saskatchewan Water Security Plan and improving water management to ensure water supplies support economic growth, quality of life, and environmental well-being.



Figure 2: Saskatchewan portion of the South Saskatchewan River Watershed Adapted from: <https://www.saskatoon.ca/community-culture-heritage/our-environment/watershed> (Last accessed on June 17, 2015).

3.1.3 City of Halifax

In Halifax, Halifax Water, a city department provides drinking water for Halifax customers by applying a multi-barrier approach to ensure the safety of drinking water from source to the tap. In 2009 Halifax Water developed a SWP plan to manage water quality of eight watersheds (Pokwock Lack, Tomeahwk Lake, Lake Major, Bennery Lake, Chain Lake and Lake Lamont, Lake Flecher, and the Musquodoboit River), and three ground water supplies providing over 79,000 customers in the Halifax Regional Municipality (Halifax Water, 2010). Approximately 75% of Halifax's source water areas are forested. Forestry activities are considered the key risk to water quality. To reduce and minimize the risk of forestry activities around watershed areas, protect water quality, and the conservation of the forest ecosystem, Halifax Water manages these forested areas. Under the Nova Scotia Environment Act, the watershed around these lakes has been designated as a protected area. Cooperation amongst Halifax Water, Nova Scotia Environment and the Labour, Dept. of Natural Resources and the local community has facilitated watershed management and monitoring activities (Halifax Water, 2015).

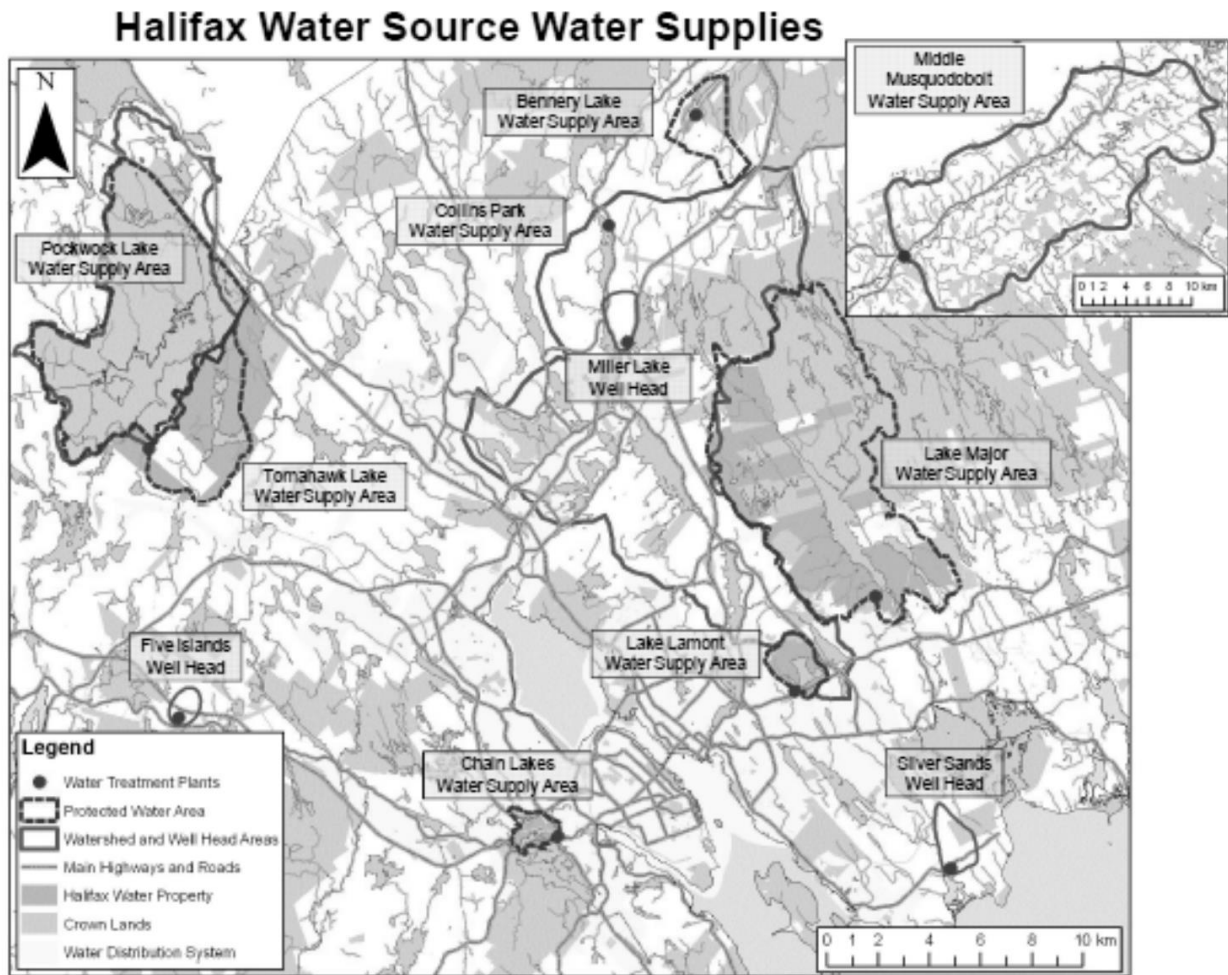


Figure 3: Halifax Water sources supplies Adapted from:
<http://www.halifax.ca/hrwc/SourceWaterProtection.php> (Last accessed on June 17, 2015).

3.1.4 City of Toronto

Both Lake Ontario and the Oak Ridges Moraine region “is an irregular ridge of sandy hills stretching 160 kilometres from the Trent River in the east to the Niagara Escarpment in the west, and contains the largest concentration of headwater streams in the Greater Toronto Area. The Moraine acts as a recharge area for groundwater” (Ontario Government, 2015) , are the source of drinking water for millions of Canadians, and they supply the people in Toronto with drinking water and other residential water uses. In Ontario, conservation authorities play a key role in managing watershed quality and quantity and have full responsibility to conduct SWP activities under provincial regulations and legislation. Conservation authorities which “are public sector organizations that develop and deliver resource management programs that safeguard our watersheds” (Ministry of Natural Resources, 2014), were created in 1946 under the Provincial Act and have the responsibility of providing leadership to implement programs for resource management and support understanding of conservation. This mission is done through communication with watershed planning (Conservation Ontario, 2015b). Each year more than \$290 million is invested to deliver a number of watershed programs such as: Watershed strategies and management, Flooding and erosion protection, Water quality and quantity, Reforestation and sustainable woodlot management, Environmental land use planning, Agricultural and rural landowner assistance, and others (Conservation Ontario, 2015a).

In the Toronto Region, Toronto Region Conservation Authority (TRCA) has the most responsibility for watershed planning and water quality protection. The results of water quality data analysis show correlation to upstream levels of urbanization. In the area of Toronto Region Conservation Authorities (TRCA’s) jurisdiction water quality continues to be impacted by a non-point source of contamination caused by urbanization effects such as sediment, nutrients and

chemicals. Also, water quality in the Greater Toronto Areas is threatened by point sources of contamination such as discharge from wastewater treatment plants and various industries (TRCA, 2015b).

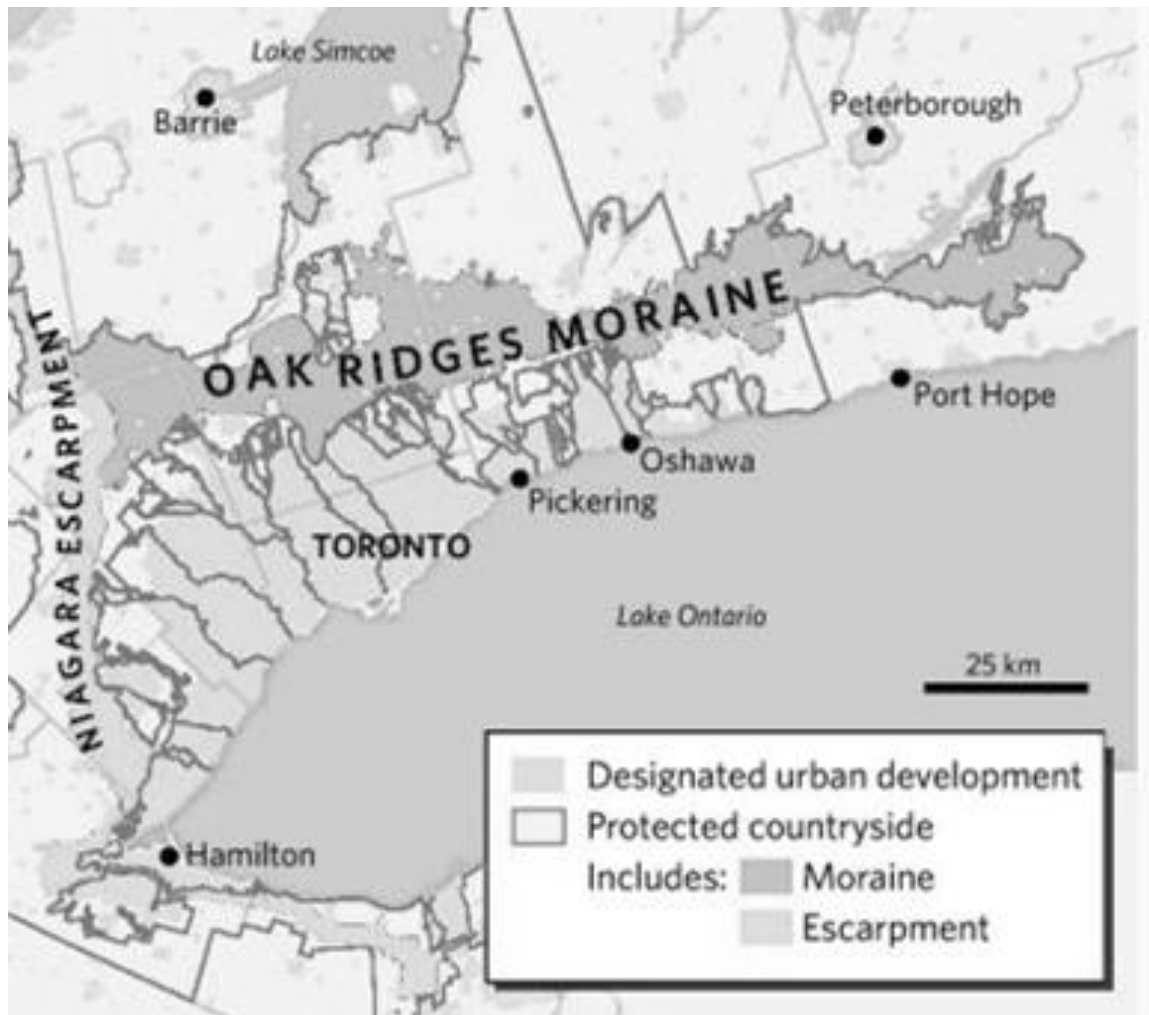


Figure 4: Toronto drinking water supplies Adapted from: http://www.thestar.com/news/gta/2011/08/10/oak_ridges_moraine_not_safe_yet.html (Last accessed on June 17, 2015).

3.2 Mixed Methods

This research employs a mixed-methods approach using a qualitative methodology including document review and a questionnaire instrument. Specific methods are identified for both Objectives 1 and 2 in this section.

Document review made use of government documents available via the websites of the selected Canadian cities. Documents included provincial water security strategy papers, SWP planning reports, and annual publications. The collected information was corroborated against the questionnaire results to provide a better understanding of the general context of SWP and the strengths and weaknesses of the SWP program in each city. For each city, the study considers specific factors—for example, the source of drinking water, risk to raw water, and water stakeholder groups and others.

A questionnaire served as a second method for gathering qualitative information to help clarify the challenges and opportunities of developing a SWP in each city. The questionnaire consisted of two sets of questions, one to be answered if there was already a SWP plan in place in the respondent's city and the other to be answered if there was no SWP plan in place (see Appendix A). Questionnaires were sent by e-mail between June and November 2014. The questionnaire required participants who had a high level of knowledge related to SWP plans to explain specific circumstances that enhance or constrain SWP implementation in their cities, with emphasis on the five capacity categories identified for the study (political, financial, institutional, technical, and human resource). To obtain the most knowledgeable responses, participants were selected based

on their job descriptions; preference was given to senior-level officials whose job responsibilities included city planning and watershed management.

A total of nine local governmental employees participated in this research, including watershed managers, a SWP planner, a managing director, senior watershed planning coordinators, a senior manager, and a water quality laboratory manager. The breakdown of participants from each of the four cities yielded three respondents from Victoria, two from Saskatoon, three from Halifax, and one from Toronto. Job titles for each participant, and their role in water management or water planning, appear in the results for their respective city. A snowball technique was used to ensure connection with the best people. The first step was developing a list of proposed participants by searching each city's website for contact information (phone numbers and e-mail addresses). Then, each participant on the list was contacted via telephone and given a brief introduction to the research; this initial contact ensured that respondents had enough expertise in their area to satisfactorily fill out the questionnaire, and that all had approval to participate. After confirming that all parties would be permitted to participate, the questionnaires were sent by e-mail. Participants were given 7 days to complete and return their questionnaires. Follow-up e-mails ensured that all participants returned their responses within the expected time.

3.3 Data Analysis

The responses of the questionnaire for each city were analyzed and qualitatively assessed to identify the supporting factors and challenges to developing SWP plans in Canadian cities. In some cases, information gained from analyzing documents was interpolated into the questionnaire responses to provide better understanding and support participants' ideas and responses.

Questionnaire responses from each city were analyzed for information in several categories, including raw water risk, facilitating factors for developing a SWP plan, and constraining factors for the same. Some categories were broken into sub-categories—for example, facilitating and constraining factors for developing a SWP plan were classified according to the schema of capacities (financial, political, institutional, technical, and human resource).

The research method for Objective 3 is a synthesis of all material and information gathered from Objectives 1 and 2.

CHAPTER 4

4.0 RESULTS

The results of the research are presented in this section. The results are organized by city, beginning in the west with Victoria and followed in order with Saskatoon, Halifax, and Toronto. In the first section of the questionnaire, participants were asked to describe the main risk to their water supplies. The goal of this question was to identify the main actions or activities that could help improve water quality. In the second section, the circumstances described by the participants are defined as either facilitating factors or constraining factors; both sets of factors are categorized in terms of political, financial, institutional, technical, and human resource capacities. However, the results show there is overlapping among the five SWP capacity elements. Some facilitating factors can lead to several facilitating factors and enhance other capacity elements and vice versa. This indicates “capacity building” for local SWP plan cannot be an absolute measurement.

The information available for any given city varied according to differences in water system performance, capacity to practice SWP, approaches to SWP, and different stages of plan development and implementation.

4.1 City of Victoria

Participants from Victoria in this study include the senior manager of watershed protection, the manager of resource planning for watershed protection, and the water quality lab manager.

4.1.1 Raw Water Risks and Conditions

The water management division of Greater Victoria's local government, the Capital Regional District (CRD) Water Department (as shown in Table 1) manages land-use activities and controls the potential effects of human activity through ownership of land contained within their drinking water supply watershed. Owning drinking water supply lands, and adjacent lands, in Greater Victoria enhances the opportunity for long-term water quality protection. In addition, the CRD Department develops water plans, policy, regulations, bylaws, and standards that collectively reduce or eliminate the risk associated with different land-use activities at water sources. The three study participants from Victoria had the same opinion regarding the main risk to the region's water sources; and all cited natural events such as wildfires in watershed areas as the main risk, with soil erosion, climate change, and ash loading listed as secondary risks. In his response, the CRD's manager of resource planning for watershed protection explained the risk of forest fire in regards to water quality:

The primary risk to water quality is a large scale wildfire in the forested water supply lands. There is the potential for substantial inputs of ash, sediment, and nutrients entering the reservoir from such an event. Since we have no filtration plant, this would be a major issue.

Table 1: Greater Victoria Water System

Question	Response
Source of Drinking Water:	Sooke Reservoir, located at Sooke Hill west of Victoria
Risks to Raw Water	Surface water resources subject to contamination from natural events. Substantial input of ash, sediment, and nutrients entering the reservoir in the event of a wildfire in the surrounding forested watershed area
Relevant Document:	Strategic Plan for Watershed Management, developed 1999
Agency Stakeholder Group:	The Capital Regional District (CRD)
Relationship to the Plan:	Plan developed by city government
Year Adopted	1999; revised 2012
Multi-Barrier Approach (MBA) in the Water Strategy	Yes
Service Population	350,000 customers

4.1.2 Source Water Protection Facilitating Factors

4.1.2.1 Political and Institutional Factors

In spite of there being no official SWP plan for the Greater Victoria water system, existing provincial regulations and initiatives play a key role in facilitating and fulfilling the task of protecting water quality at the source. As required by provincial drinking water regulations, Victoria's water supplies—which provide safe drinking water to approximately 350,000 customers—fall under the requirements of the BC Drinking Water Protection Act (2001), and the BC Drinking Water Protection Regulation (2003; CRD, 2014). The manager of resource planning

for watershed protection in the CRD indicated that provincial acts are the main factors that facilitate the protection of drinking water quality in Greater Victoria:

The most important factor was the Provincial Act (its provisions were also incorporated into a Capital Regional District bylaw). This Act was generated by the dissolution of the Greater Victoria Water District (the water supplier since 1949) and the transfer of the water supply function to the Capital Regional District to improve political representation and accountability.

This change clarified the roles and responsibilities for managing and protecting drinking water quality from natural events and human activity, in addition to developing water management plans to understand the effects of land-use activities on water quality. The cooperative approach to managing water resources and controlling land-use activities in Greater Victoria is centralized under a single leading authority (the CRD Water Department), which facilitates the improvement of water management policies and strategies.

The requirements of the Capital Region Water Supply and the Sooke Hills Protection Act are the other important legal precedents that fulfill drinking water quality protection. The Act requires the CRD Water Department to prepare a strategic plan for the watershed areas focused on the next 20 years. The vision statement of the strategy emphasizes the primary goal, which is ensuring high quality drinking water at the source. The strategy also highlights the importance of SWP as the first barrier in a multi-barrier approach. The strategy fulfills the goal of SWP by integrating a risk management framework with adaptive management. The adaptive management approach aims to improve the understanding of the overall results of limnological, hydrological, ecological, and geological processes on the quality of water sources (CRD Water Department, 1999; Strategic Plan for Water Management, 1999). This understanding helps in developing

options in decision-making to reduce the impact of land activities near watershed areas. The participants all agreed that this strategy was not an official SWP plan, but could fulfill the goal of one. The need for a SWP plan was considered a low priority, as the manager of resource planning for watershed protection explained: “Although the Strategic Plan is not considered a drinking water protection plan under the specific requirements of the Drinking Water Protection Act, it does fulfill this general purpose.” The senior manager of watershed protection and integrated water service in the CRD also had the same opinion: “Due to the dedicated purpose of the land to supplying high-quality drinking water, I do not see a need for a source water protection plan.”

4.1.2.2 Financial Factors

The other critical element that facilitates the protection of the watershed drinking water quality in Greater Victoria is the integration of both land usage and water management through the jurisdiction of the CRD Water Department. According to the manager of resource planning for watershed protection, the Watershed Protection Division manages the 20,000 hectares of CRD-owned land in the existing and future water supply catchments for the Greater Victoria Water Supply System (GVWSS), “Within this area, no public access, commercial logging, farming, mining or recreation is permitted and no use of herbicides, pesticides, or fertilizers is allowed. This SWP barrier eliminates many of organic and inorganic chemicals that can contaminate the source water and virtually eliminates the potential for human disease agents being present” (CRD, 2013). The CRD’s ownership of so much land in Greater Victoria facilitates risk assessment operations, ecological inventories and analysis, and wildlife management. The CRD’s senior manager of watershed protection and integrated water service considered the CRD’s land ownership to be an opportunity to ensure a supply of high-quality drinking water for the city of Victoria in the long term. “We are in a unique position where the Region owns 90% of the watershed land base and

public/industrial access is restricted.” Watershed management plans and implementation have been developed successfully. As the manager and services planner in the CRD mentioned, owning catchment and non-catchment lands for risk reduction and protection promotes watershed quality through prevention. This is done by the prevention of public access to water supply lands, careful land stewardship, wildfire prevention and suppression programs, water quality monitoring, watershed security programs, ecological restoration of disturbed areas, and risk reduction activities targeted as the greatest threats to source water quality.

Table 2: SWP Facilitating Factors, Victoria

Capacity Component	Facilitating Factor
Political	<ul style="list-style-type: none"> • Political acts and support; clarification of role and responsibilities (CRD) • Capital Region Water Supply and Sooke Hills Protection Act requires drafting of 20-year strategic plan (2012)
Financial	<ul style="list-style-type: none"> • Region owns 90% of watershed land base • public/industrial access restricted so drinking water is high quality
Technical	Not Reported
Institutional	Not Reported
HR	Not Reported

4.1.3 Source Water Protection Constraining Factors

4.1.3.1 Financial Factors

Despite political support for managing watershed quality and implementing watershed management actions and policies, the participants indicated that a lack of financial resources to continue to manage these policies and actions will actually restrict the improvement of the water system management in Greater Victoria in the future (a similar problem affects the Halifax SWP

plan, as will be discussed in section 4.3). Protecting water quality at the source and preventing risk from land-use are long-term processes and require a flexible annual budget. When asked to describe the constraining factors that stand in the way of improving the protection program in Greater Victoria, the manager of the resources planning for watershed protection mentioned the tight deadline for preparing the strategy plan as well as “the need to operate within a set annual operational budget and a five-year capital budget. Implementation actions are prioritized and set out in a three year Service Plan.”

Table 3: SWP Constraining Factors, Victoria

Capacity Component	Constraining Factor
Political	Not Reported
Financial	Must operate within a set annual operational budget and a 5-year capital budget
Technical	Not Reported
Institutional	Not Reported
HR	Not Reported

4.2 City of Saskatoon

The participants representing Saskatoon included the senior watershed planning coordinator and the watershed coordinator.

4.2.1 Raw Water Risk and Conditions

The South Saskatchewan River Watershed supplies the city of Saskatoon with its drinking water. The watershed is also considered an important supplement to support various types of land-use activities such as agriculture, irrigation, and urban uses including wastewater and storm water discharge. According to the South Saskatchewan River Watershed Stewards Inc. (SSRWSI), the

activity that consumes the largest portion of SSR water use is agricultural irrigation (SSRWSI, 2014b). The two participants in the city of Saskatoon agreed with issues regarding the impacts of agriculture. These were noted as the main risks, according to the SSRWSI (2014b):

Mercury is perhaps the most significant risk to water quality, as the flooding of Lake Diefenbaker upstream of the Gardiner Dam dissolved natural mercury in what was previously agricultural land, pasture, or native vegetation. Algae blooms in Lake Diefenbaker are another reoccurring problem, as many of the upland agricultural areas drain into the lake, causing problems with nitrogen concentrations.

The Watershed Coordinator of the South Saskatchewan River Watershed Stewards Inc. (SSRWSI) mentioned that different types of land use in the South Saskatchewan River area (see Table 4), which included agricultural activities and other industrial activities such as mining, processing of oil sands, and landfills, have altered and affected the watershed quality and caused different water quality issues such as turbidity, dissolved organic carbon, and increased water temperature.

Table 4: Saskatoon Water System

Question	Response
Source of Drinking Water	South Saskatchewan River, fed by the Bow, Red Deer, and Oldman Rivers; it passes through Lake Diefenbaker before reaching Saskatoon
Risk to Raw Water	<ul style="list-style-type: none"> Upstream issues from Alberta: urban issues (development, waste water effluent); intensive agriculture; loss of native habitat along the river (wetlands, native prairie) industrial development (mining, petroleum), landfills; ground water wells Other water quality issues: turbidity; dissolved solids, nutrients (phosphorous and nitrogen), and organic carbon; decreased oxygen levels: increased water temperature
Relevant Document	South Saskatchewan River SWP Plan
Agency Stakeholder Group	Water Security Agency, SSRWSI
Relationship to the Plan	The South Saskatchewan River Watershed is divided into three watershed planning areas: North, Lake Diefenbaker, and West. Saskatoon is part of the North area of the plan
Year Adopted	2007
MBA in the Water Strategy	Yes
Service Population	254,000 customers

4.2.2 Source Water Protection Facilitating Factors

4.2.2.1 Political Factors

The 25-Year Saskatchewan Water Security Plan (WSA, 2012), which includes actions and arrangements for long-term watershed management plans to ensure safety of watershed quality, was developed by provincial initiatives for water conservation and water quality management.

After the North Battleford contamination inquiry in 2002, the plan was developed to provide a variety of tools, regulations, policies, and monitoring measures intended to protect drinking water quality and prevent contamination at the source. The strategy involves all communities, stakeholders, First Nations groups, and local governments to develop objectives and implement a SWP strategy (SWA, 2012).

In addition to its role in drafting the Water Security Plan and paving the way for SWP actions, an agency of Saskatchewan's provincial government (the Saskatchewan Watershed Authority) was tasked with developing a SWP plan in 2007. Additionally, in order to implement all SWP plans, the government brings together all stakeholders and other political entities to identify common concerns, guarantee that all stakeholders' interests were taken into account in the decision-making process, and mediate potential conflicts among stakeholders. The plan, with the support and partnership of the South Saskatchewan River Watershed Stewards Inc. (SSRWSI), identifies the key actions that are needed to address identified threats to water quality and puts forth a set of recommendations to ensure the protection of drinking water (SWA, 2012).

4.2.2.2 Institutional Factors

Under the terms of the South Saskatchewan River Watershed SWP, actions are implemented by the watershed coordinator. The coordinator also mentioned that cooperation is essential to integrate work among multiple agencies, with the SSRWSI being one of the lead organizations. The strategy, based on communication and partnership work, addresses several SWP actions to ensure protection of water quality and the ecosystem, (SWA, 2012). The SWP plan also has a goal of increasing awareness of local water issues and reducing activities that harm water quality; the goal involves getting buy-in for the plan from all residents in rural and urban areas and asking them to do their part (SSRWSI, 2007).

4.2.2.3 Technical Factors

The technical support needed for implementation of the SWP plan includes data availability, water quality assessment, and dissemination of knowledge related to water issues. Assessment and monitoring programs have been developed by the SSRWSI to protect the water sources. According to the watershed coordinator of the SSRWSI: “The SSRWSI worked with a graduate student at the University of Saskatchewan to develop a water quality assessment of the South Saskatchewan River Watershed.” The assessment program includes test sampling to ascertain the characteristics of water quality; identifying threats to water quality; assessing risks associated with land use, activities and urban development; and designing a monitoring program (SSRWSI, 2013). The data collected by the program can provide information to help inform the SWP plan with respect to identification of any threats that may lead to water contamination.

Table 5: SWP Facilitating Factors, Saskatoon

Capacity Component	Facilitating Factor
Political	Clear role and support from government of SK; 25-Year SK Water Security Plan, SWP plan 2007, and SSRWSI support
Financial	Not Reported
Technical	Water quality assessment and monitoring programs
Institutional	Communication and partnership work
HR	Not Reported

4.2.3 Source Water Protection Constraining Factors

4.2.3.1 Political, Financial, Institutional Factors

The river watershed has economic benefits for multiple stakeholders and allows shared land and water uses. Good communication, sharing of responsibilities and a commitment to financial and social support are necessary to facilitating SWP actions and increasing awareness among all stakeholders. In the case of Saskatoon, the senior watershed planning coordinator indicated a lack of commitment to cost-sharing; he also indicated that responsibilities, at both the provincial governmental and local level, are restricted in regards to implementing the SWP plan in Saskatoon. He explained his concern:

Development of the plan is not normally difficult; lack of implementation is the greatest barrier to success and this is directly influenced by commitments of both resources and money from federal, provincial, [and] municipal governments and First Nations and Métis people and stakeholders. Everyone can agree on what [is needed;] the argument is always on who pays.”

4.2.3.2 Technical Factors

Despite the policies and tools in place to protect water quality and address water issues, the two participants from the city of Saskatoon have the same opinion regarding the position of the South Saskatchewan River Watershed SWP plan. According to the senior Watershed Planning Coordinator, “watershed plans . . . should be reviewed and updated to remain current every 5–10 years. “Population growth, intensive agriculture, and other forms of urban land use are likely to pose sustained threats to source water quality. The watershed coordinator described the existing SWP strategy as an “outdated plan” because new issues should and must be addressed. In

particular, he cited “invasive species (aquatic and plant) and population growth” as issues of concern.

Table 6: SWP Constraining Factors, Saskatoon

Capacity Component	Constraining Factor
Political	Lack of commitment to resources for SWP from federal, provincial, municipal senior government officials
Financial	Unwillingness of federal, provincial, municipal governments and First Nations and Métis people and stakeholders to assume financial burden of plan
Technical	Not Reported
Institutional	Lack of communication and financial commitment among multiple levels of government and local people
HR	Not Reported

4.3 City of Halifax

The participants from the Halifax Water Agency include the Halifax watershed manager, the director of water services, and the source water planner.

4.3.1 Raw Water Risk and Conditions

The Halifax Water Agency manages the city’s municipal drinking water supply including the main watershed areas, groundwater supplies, and small water systems within the city that supply between 11 and 300 customers (see Table 7). In their responses to the questionnaire, the Halifax Water Agency participants emphasized the risks to municipal water supplies in Halifax were due to the water supply’s location and nearby land use activities. The director of water services revealed that recreational water activities and public pressure are the main issues

potentially affecting raw water quality in Halifax. Recreational and public activities such as swimming, camping, boating, and fishing are water-dependent and can negatively influence water quality; for example, swimming activities have the potential to spread bacterial pathogens to the local drinking water supply. Activities related to expanded urban development, such as road maintenance and associated activities, have caused water quality alteration on surface water supplies; road salt and hazardous materials carried by vehicles along roadways were cited as potential hazards. The source water planner at the Halifax Water Agency emphasized how municipal land use can affect the local water supply for the Halifax water system:

For surface water supply source areas, which are more remote and contained within wooded areas, the main risk is a forest fire. For other water supply areas, including surface and groundwater supplies that are impacted by residential areas without municipal septic services, the risks include on-site septic systems and storm water runoff, which carries all sorts of pollution, and recreational activities including boating and off-highway vehicle use; and especially for those that are not provincially designated, the main risk is the lack of regulations and municipal by-laws to help protect the water supplies from land use planning and development activities.

Natural catastrophic events such as fires, native and invasive forest insects such as Brown Spruce Longhorn Beetles (BSLBs), and wind storms at the main watersheds—Pockwock, Major, and Bennery—could impact water quality, according to the Halifax watershed manager. The agency often cooperates with other government bodies to improve and maintain water quality; one such cooperative project was a 2009 effort to limit infestation by the brown spruce longhorn beetle (BSLB) through forest management in the Lake Major watershed area (Halifax Water Agency, 2010).

Table 7: Halifax Water System

Question	Response
Source of Drinking water	Eight watersheds (Pockwock Lake, Tomahawk Lake, Bennery Lake, Lake Major, Chain Lake, Lake Flecher serves, The Musquodoboit Lake, Lake Lemont, and wellheads provide ground waters).
Risk to Raw Water	<ul style="list-style-type: none"> • Main watersheds (Pockwock, Major, and Bennery) are at risk from natural events that could impact water quality (e.g. fire, disease, or wind storms). • Other water systems with no specific watershed regulations in development and agricultural-use areas: problems range from nutrient loading to storm water run-off. • For surface water, the main risk is from roadways and contamination by road salt and hazardous materials carried by vehicles. • For surface sources in remote wooded areas, the main risk is forest fire. • For other surface and ground water supplies, the risk comes from contamination from residential areas without septic services. • Intrusion by recreational activity or public pressure to make the land available for recreation is also a problem.
Relevant Document	Halifax SWP Plan
Agency Stakeholder Group	Halifax Water Agency, plus three watershed committees: Pockwock Lake Watershed Management Committee, Lake Major Watershed Advisory Board, and Bennery Lake Watershed Management Committee
Relationship to the Plan	The plan is developed by the city.
Year Adopted	2009
MBA in the Water Strategy	Yes
Service Population	Over 79,000 customers

4.3.2 Source Water Protection Facilitating Factors

4.3.2.1 Political Factors

Political supporting factors, in the case of Halifax, are defined as any governmental initiative (provincial or local level) that has facilitated the development or improvement of the SWP plan. The Province of Nova Scotia's Drinking Water Strategy (2002) is based on the recommendations of the Walkerton inquiry and serves as a significant provincial initiative promoting the protection of water supplies at the municipal level. New regulations have been put in place that mandate regular testing of all public drinking water supplies; in addition, land-use bylaws require officials to address local water issues and develop sensible solutions for the protection of drinking water supplies. For example, The Public Water Supply Area the "Lake Flecher watershed land areas" is protected under Halifax Regional Municipality Legislation and Bylaws (Halifax Water Agency, 2015b).

The strategy consists of several initiatives, which include actions, tools, education programs, and the promotion of human resource expertise. These initiatives, in turn, work collectively to protect and manage municipal drinking water supplies. The strategy stresses communication between parties to ensure the sustainability of the SWP plan. The strategy clarifies the roles and responsibilities in the integrated work among multiple government levels, businesses, and other stakeholders (Nova Scotia Environment and Labour, 2002).

The multi-barrier approach is recognized as the hallmark of the most comprehensive strategy to protect drinking water quality in the municipal context. The protection plan for the Lake Major and Pockwock watersheds in Halifax, designed under provincial legislations "the Nova Scotia Environment Act". The Act, utilizes a multi-barrier approach to protect drinking water

quality and all activities on the two watersheds areas are regulated such as restrictions on hunting, fishing and the use of motorized vehicles (Halifax Water Agency, 2015a).

At the municipal level, the most important political factor facilitating a SWP plan in Halifax is ownership of vulnerable lands by an autonomous utility. The Water Agency's land acquisition program has secured 84% of the three main protected water areas (a total of 13,230 hectares). For example, Tomahawk Lake Watershed is not designated but is primarily owned by Halifax Water (~75%) and protected under the Halifax Regional Water Commission Act. Over 95% of the Chain Watershed area is owned and managed by Halifax Water and the Crown. More than 90% of the Lake Lemont Watershed land area is owned and managed by Halifax Water, and 10% of Bennery Lake Watershed is owned by Halifax Water and protected under provincial designation and regulations (Halifax Water Agency, 2015b). According to the director of water services, this is the most importance factor that facilitated the development of a SWP plan in Halifax: "Because we are an autonomous utility, and we control most of the land, technical factors such as identifying risks, emergency response, etc., are the most important factors."

Acquisition of land allows an organization to manage the use of chemicals, limit access to water supplies, and control or restrict land use activities that have cumulative effects on the water quality. Also, operations needed to maintain high drinking quality, such as risk assessment, regular monitoring, and emergency response, can be carried out more easily through a land acquisition program. Recently, the Halifax Water Agency started managing the forested land around the watersheds and operating a water-crossing inspection program. This program requires inspection every 5 years for all water crossing structures (such as bridges) to identify the areas that need repair (Halifax Water Agency, 2010).

4.3.2.2 Financial Factors

Financial support plays a key role for managing the cost of SWP implementation, assessments, monitoring, and other expenses. The watershed manager referred to an annual budget of approximately \$300,000 to conduct SWP activities. The operating budget comes from a variety of sources, including water rates, property taxes, and sewers and water services fees.

4.3.2.3 Technical Factors

The three study participants from Halifax cite the availability of technical support as an important factor for improving the implementation of the SWP plan. Facilitating technical factors in Halifax include the implementation of a water quality baseline, development of water quality monitoring programs, and scientific research. The watershed manager mentioned the Water Agency's success in preventing contamination and providing safe, high-quality drinking water through the implementation of water-quality baselines to identify and eliminate contamination such as bacteria and heavy minerals. Implementing water-quality baselines involves gathering scientific evidence, working to understand the cause of contamination, and communicating with stakeholders or those who cause the contamination. To protect source water supplies in Halifax, the Water Agency has developed a monitoring program for its distribution system. Monitoring programs at the watershed level manage water quality and biological and chemical concerns. According to the source water planner, implementing a chemical-use management program has been a success for the SWP of municipal watersheds. Monitoring water quality at the distribution system is also important to meeting provincial requirements from a public health perspective. Across the distribution system, 88 samples are taken weekly to check for chlorine, *E. coli*, and total coliform bacteria levels (Halifax Water Agency, 2014).

To promote responsible watershed stewardship, the Halifax Water Agency works with education programs and has expanded the water project based on developing scientific knowledge. The watershed manager declared that the Halifax Water Agency “welcomes the opportunity to speak at conferences and workshops to improve communication and broaden SWP knowledge to those interested.” In addition, several research projects related to SWP have been undertaken through a partnership with Dalhousie University and the Natural Science and Engineering Research Council (Halifax Water Agency, 2010). The watershed manager mentioned participating in intensive collaboration with postsecondary educational institutions to conduct advanced research to increase the understanding of the risks to water quality and to establish possible solutions to mitigate source contaminations.

4.3.2.4 Institutional Factors

Clear leadership is a must for managing watershed supply issues such as increasing the ability to protect drinking water quality and the effectiveness of SWP enforcement. The Halifax Water Agency, with support from local committees and trained staff, has the leadership to manage water quality and increase awareness among communities about water issues and conditions. Although the utility derives its powers to undertake SWP activities and implementation from provincial statutes and regulations established by the Nova Scotia Utility and Review Board, the municipal government has no direct responsibility for SWP activities in Halifax. The watershed manager stated that, “In the Halifax [Water Agency] we are [an autonomous] utility which is separate from the municipal government. The municipal government has no direct responsibilities related to SWP activities other than to protect water quality through the municipal statement of interest.”

In the case of Halifax, communication plays an important role in supporting development of the SWP plan; for example, communication between Halifax Water and various government agencies produced a cooperative effort to manage forest land and reduce the adverse impacts of BSLB infestation on the watershed. Also, the Halifax Water Agency worked with committees of the Nova Scotia Department of Natural Resources to develop best management practices (Halifax Water Agency, 2010). The director of water services referred to the role of communication with other stakeholders to increase the efficiency of SWP implementation. Meaningful communication and sharing responsibility are needed to reduce risk at the local drinking water supplies. “We do have some communities on the fringes of our watersheds, so our impact as a large landowner with restricted access to our land, and the resulting impact on the communities, can be a social issue.” Recently, the Halifax Water Agency has formed partnerships with stakeholders, such as trail-hiking and geocaching groups, to design acceptable access areas and practices that will not compromise water quality safety of the watershed.

4.3.2.5 Human Resources Factors

The Watershed Manager cited the role of leadership in facilitating the SWP plan for Halifax, emphasising “commitment from executive staff to identify a watershed department (expertise) and the autonomy to let the watershed [agency] develop the plans.” Training opportunities and selective hiring have increased the numbers of Halifax Water Agency staff who have the necessary knowledge base to manage drinking water resources, monitor programs for operational sites, and observe the effects associated with recreational activities. These training and hiring opportunities have increased both for the Halifax Water Agency and for Nova Scotia’s environmental organizations. For example, in 2002 alone, the program to protect and monitor municipal Nova Scotia drinking water supplies increased its numbers of expert staff to include a

number of different specialists, such as hydro-geologists, inspectors, watershed planners, drinking water supervisors, and water monitoring technicians (Nova Scotia Environment and Labour, 2002). The staff was hired by either the provincial government or the Halifax Water Agency with the goal of increasing efficiency in monitoring water issues and implementing the SWP plan in a scientific and knowledgeable manner. However, the role of public participation in the process of protection and management of water quality has also been recognized. The SWP planner emphasized the importance of increasing public awareness and promoting education programs. Proposed methods include: “public communication and awareness—signage, educational programming, publications, [and] newsletters.”

Table 8: SWP Facilitating Factors, Halifax

Capacity Component	Facilitating Factor
Political	<ul style="list-style-type: none"> • New municipal land-use bylaws • Provincial Drinking Water Strategy (2002) • Land Acquisition Program secured 84% of protected water areas
Financial	Adequate funding
Technical	<ul style="list-style-type: none"> • Water quality baselines helped eliminate contaminants • Water quality monitoring, chemical use management, emergency and critical infrastructure protection • Scientific research, water information, and education programs
Institutional	<ul style="list-style-type: none"> • Clear water agency leadership • Stakeholder support and buy-in and multi-communication and sharing responsibilities • Collaboration with governing, regulatory and enforcement agencies
HR	<ul style="list-style-type: none"> • Human Resources commitment to give individual watershed agencies autonomy to develop plans • Training and hiring expertise • Public participation and roles: Signage, educational programming, newsletters, regulations, bylaws

4.3.3 Source Water Protection Constraining Factors

4.3.3.1 Political, Institutional Factors

A SWP program can be difficult to develop and implement given that any consensus-based approach requires a long-term commitment and cooperation among multiple stakeholders and provincial and local governments (Nova Scotia Environment and Labour, 2002). The watershed manager concluded that the governments parties at both the municipal and provincial levels need to support the SWP plan. This is the most significant political factor that limits the improvement and upgrade of the SWP plan in Halifax.

When asked to describe the main risk regarding raw water in Halifax, all participants cited the lack of watershed regulations to control land-use activities; this lack of legal authority limits the efficacy of the SWP plan for municipal drinking water supplies. The participants' points of view seem to be consistent regarding the need to ensure that adequate watershed legislation and municipal bylaws minimize risk around watershed areas. The watershed manager explained that the water risk to small systems and areas was not considered in the watershed regulations. "Customers with no specific watershed regulations . . . are located in developed areas and one in an agricultural area. Problems range from nutrient loading to storm water run-off. At the moment there is no immediate concern of industrial run off as no industrial use exists within the watersheds."

4.3.3.2 Financial Factors

In evaluating the status of the SWP plan in Halifax, this study finds that the plan has been implemented effectively and has been managing all municipal drinking water supplies since 2009. Two participants indicated that insufficient funding could restrict improving the outlook of the

SWP plan in Halifax. The SWP process is a long-term commitment, and thus it needs to address the cost of regular monitoring, maintenance and replacement of infrastructure, and periodic hydrological studies and technical assessments. In addition, the plan must address the cost of employing external expertise and training staff to ensure that the plan is running smoothly and address new issues that might adversely affect the local water quality. The director of water services in his response noted the need for financial resources to cover the external needs of the SWP plan: “We do not have the financial resources to do everything we would like to, but we are in a good position overall.”

Table 9: SWP Constraining Factors, Halifax

Capacity Component	Constraining Factor
Political	<ul style="list-style-type: none"> • Lack of support from municipal and provincial regulators • Lack of regulations to protect water supply area; lack of expertise at regulator level
Financial	Insufficient long-term funding
Technical	Not Reported
Institutional	Biggest risk: informal recreational activity around water sources, public pressure to make the land available for recreation
HR	Not Reported

4.4 City of Toronto

The results for Toronto have been drawn from the questionnaire response of a single participant, the city's Manager of Hydrogeology.

4.4.1 Raw Water Risks and Conditions

A broad range of natural factors (e.g., climate events) and human factors (e.g., agriculture, industry, and land development) threaten the quality and quantity of Lake Ontario's water. The Manager of Hydrogeology for the City of Toronto, which is working to assess and protect its ground water resources at the watershed level, indicated that land development in Toronto is one of the most significant factors affecting raw water quality. Based on the approved assessment report in the Toronto and Region Source Protection Area (2012), there are several potential sources of fecal contamination that could increase the amount of waterborne pathogens in Lake Ontario. These sources of contamination include river and stream discharge, sewage treatment plant waste, and other shoreline sources ranging from wildlife droppings to diverse urban and agricultural runoff activities (TRCA, 2012). The inventory and assessment of natural and human influence factors on Lake Ontario through monitoring and assessment programs are key to controlling and protecting water quality, ensuring public safety, and maintaining water quality for current and future generations. In the Oak Ridges Moraine Region water quality is influenced and threatened by increasing of urbanization activities and increasing its load of metals and organic contaminants. In the area within TRCA's jurisdictions, water quality conditions are considered in most wells fair or poor because of human activities (TRCA, 2015a).

Table 10: Toronto Water System

Question	Response
Source of Drinking Water	Lake Ontario, The Oak Ridges Moraine Region
Risk to Raw Water	Land development
Relevant Document	CTC Source Protection Region (Credit Valley, Toronto and Region and Central Lake Ontario)
Agency stakeholder Group	<ul style="list-style-type: none"> • CTC Source Protection Region; Government of Ontario • Toronto Region Conservation Authority.
Relationship to the Plan	Toronto and Region are part of the CTC Source Protection Proposal Plan
Year Adopted	Anticipated 2015
MAB in the Water Strategy	Yes
Service Population	over 3,800,000 people

4.4.2 Source Water Protection Facilitating Factors

4.4.2.1 Financial and Political Factors

In the case of Toronto, financial assistance is obtained by provincial initiatives, as the Manager of Hydrogeology at the City of Toronto stated regarding SWP policies and actions. The Government of Ontario developed conservation authorities, improving and remediating water quality have been addressed in the Toronto Region Conservation Authority (TRCA) watershed plans and policies. Since 2007, more than \$500,000 has been invested in a comprehensive monitoring program, the Great Lakes Nearshore Monitoring Program (TRCA, 2014d). In addition,

the Drinking Water Stewardship Program offers supporting funds to individuals and organizations who contribute to protecting municipal drinking water sources (Simms et al., 2010).

4.4.2.2 Technical and Institutional Factors

In the aftermath of the Walkerton *E. coli* contamination tragedy in 2000, which resulted in seven deaths and damaged public trust in the municipal water supply, the Government of Ontario intensified its technical and institutional efforts to assess the factors that threaten local water sources (ground and surface waters) and ensure the safety of drinking water quality. The Manager of Hydrogeology referred to the TRCA's role in facilitating development of Toronto's proposed SWP plan on a technical level. In partnership with government agencies, watershed councils, and member municipalities, the TRCA has helped establish monitoring programs at the province-wide level. At the groundwater level, the TRCA (in partnership with the Ministry of the Environment) developed a monitoring network to gather and analyze data from well water, providing an early-warning system for changes in water quality influenced by climate conditions and human uses (TRCA, 2014a).

The TRCA's Regional Watershed Monitoring Program (RWMP), in partnership with the Ontario Ministry of the Environment (OMOE), has been monitoring surface water quality since 2002 with a program that spans nine watersheds. Surface water quality data is tested and analyzed based on a standard set of water quality parameters, such as levels of nutrients, bacteria, and heavy metals (TRCA, 2014b). A broad range of impacts on surface water quality from land use can be determined in great detail, and the information can influence decisions to regulate such activities as land development, urban uses, or agriculture.

The Clean Water Act (CWA) of 2006 introduced the first set of regulations for drinking water source protection and mandated that municipalities develop their own SWP plans. The CWA

advocated a science-based, multi-stakeholder process and laid the ground to establish the Toronto and Region Source Protection Authority within the Credit Valley, Toronto and Region and Central Lake Ontario (CTC) Source Protection Region (TRCA, 2014c). Under the requirement of the CWA and Ontario regulations, an assessment report based on technical studies done in the Toronto Region Source Protection area (TRSPA) was approved by the OMOE in 2011. The assessment report provided information on vulnerable areas, as well as detailing significant natural events (such as climate change) and human uses such as agriculture and urban development that negatively influence the quality of ground and surface water in Lake Ontario (CTC, 2014). The available data on water quality threats helps to determine the actions needed to reduce contamination, monitor the process, and ultimately to implement SWP in the TRSPA—which, as the Manager of Hydrogeology anticipated, is supposed to be implemented in 2015.

Table 11: SWP Facilitating Factors, Toronto

Capacity Component	Facilitating Factor
Political	The role of provincial government to support developing the TRCA
Financial	Financial support from provincial government
Technical	Strong in-house technical capability at the TRCA
Institutional	Partnerships with governmental agencies, watershed councils, and member municipalities
HR	Not Reported

4.4.3 Source Water Protection Constraining Factors

4.4.3.1 Political Factors

In the post-Walkerton era, the provincial government's role in managing source water quality through identification of threat areas for waterborne pathogens has increased. According to statistics from the Minister's Annual Report on Drinking Water (2012), 99.87% of tests from municipal residential drinking water systems in Ontario met safety standards (Ontario's Water Sector Strategy, 2013). However, the Manager of Hydrogeology indicated that the government's role in protecting private wells, compared with its ability to protect municipal resident supplies, has been limited until quite recently. The absence of regulations to protect municipal private wells, including mandatory monitoring programs, increased water testing, regular data collection and analysis, and encouragement and education of local well users, has contributed to the prevalence of pollution and waterborne pathogens that affect public health. In 1996, the Report on the State of Canada's Environment indicated that about 20–40% of rural Canadian wells were polluted with significant concentrations of nitrates or fecal coliform bacteria (Auditor General of British Columbia, 1999). The lack of authority to improve regulations and bylaws to protect private wells can make remediation of contaminated wells more difficult and expensive over time. Several examples of the groundwater contamination in Ontario have shown the complexity of the groundwater remediation process. For example, in the area of Elmira, Ontario, it is estimated that about 30 years will be needed to clean up the town's groundwater supply after contamination by toxic

chemicals; the total cost is expected to reach \$50 million, a price tag that includes both the remediation and arrangements for an alternative water supply (Auditor General of British Columbia, 1999).

4.4.3.2 Financial Factors

In spite of the extant proactive technical tools and the TRCA tools to protect municipal waters, the financial resources for further SWP appear to be limited. For example, the Manager of Hydrogeology referred to two actions requiring external funds that would improve the current level of SWP implantations in Toronto. First, additional funds are required to implement social and educational programs to promote stewardship, outreach, and threat verification. Local people in Toronto must be knowledgeable and aware of their responsibility for effective land-use practices that will help to manage and protect their water sources. Social investment in training and education will increase the city's capacity to implement its SWP plan.

Secondly, additional financial resources are needed to compensate landowners for property taken under TRCA control. The examples of the cities of Halifax and Victoria have shown that placing tracts of land under the jurisdiction of water agencies can achieve and maintain long-term water quality protection. The costs of stewarding water sources and implementing water protection can be prohibitively expensive for landowners in some cases; consequently, cooperation agreements between local government and landowners is necessary for guiding land use and human activity in accordance with best practices. In Toronto, the absence of financial compensations for landowners reduces their desire to comply with governmental regulations to protect sources of drinking water.

Table 12: SWP Constraining Factors, Toronto

Capacity Component	Constraining Factor
Political	Lack of ability to protect private wells
Financial	<ul style="list-style-type: none"> • No compensation • Lack of funds to support education programs
Technical	Not Reported
Institutional	Not Reported
HR	Not Reported

4.5 Summary

This chapter analyzed the results of the synthesized information from the questionnaires, government documents, and municipal websites of the four case study cities. According to the results of this research, the factors that affect and influence the development of SWP plans in metropolitan areas of Canada vary from city to city.

In the cases of Halifax and Victoria, provincial initiatives and financial support for acquiring and managing land provide a significant opportunity for protecting water quality and establishing the authority to control use of the land adjoining watersheds. Institutional arrangements in both Halifax and Victoria—specifically, the clear leadership role of an

autonomous water agency—support the process of water source protection with a framework of regulations, bylaws, and best management practices.

In the cases of Toronto and Saskatoon, it took outbreaks of water-borne illnesses—*E. coli* at Walkerton, Ontario, in 2000 and *Cryptosporidium* at Battleford, Saskatchewan, in 2001—to convince the provincial governments of Ontario and Saskatchewan to increase technical support, improve water quality issue assessments, and monitor programs with the purpose of determining which issues should take priority. Provincial support in the development of a water security strategy can include SWP activities and policies that protect local water sources.

The constraining factors and challenges that affect the development of a SWP plan often include inadequate financial support, which was listed as the most common constraint in all four cities. SWP processes require long-term financial support for updating data and addressing new issues that affect and threaten the quality of water at the local level. Additionally, the lack of institutional arrangements, the absence of necessary regulations for addressing local problems such as the effects of recreational activities in Halifax, and the lack of protection for private wells were also named as constraints for Halifax, Saskatoon, and Toronto.

Implementing a SWP plan in the metropolitan areas of Canada is a complex process and is influenced by political, financial, institutional, and human resource factors.

Table 13: SWP Facilitating Factors

City	Political	Financial	Technical	Institutional	Human Resources
Victoria	Political acts and support; clarification of role and responsibilities (CRD) Capital Region Water Supply and Sooke Hills Protection Act requires drafting of 20-year strategic plan (2012)	Region owns 90% of watershed land base. Public/industrial access restricted so drinking water is high quality.	Not Reported	Not Reported	Not Reported
Saskatoon	Clear role and support from government of SK; 25-Year SK Water Security Plan, SWP plan 2007, and SSRWSI support	Not Reported	Water quality assessment and monitoring programs	Communication and partnership work	Not Reported
Halifax	New municipal land-use bylaws. Provincial Drinking Water Strategy (2002). Land Acquisition Program secured 84% of protected water areas.	Adequate funding	Water quality baselines helped eliminate contaminants. Water quality monitoring, chemical use management, emergency and critical infrastructure protection. Scientific research, water information, and education programs	Clear water agency leadership Stakeholder support and buy-in and multi-communication and sharing responsibilities Collaboration with governing, regulatory and	Human Resources commitment to give individual watershed agencies autonomy to develop plans. Training and hiring expertise. Public participation and roles: Signage, educational programming,

				enforcement agencies	newsletters, regulations, bylaws
Toronto	The role of provincial government to support developing of TRCA	Financial support from provincial government	Strong in-house technical capability at the TRCA	Partnerships with governmental agencies, watershed councils, and member municipalities	Not Reported

Table 14: SWP Constraining Factors

City	Political	Financial	Technical	Institutional	Human Resources
Victoria	Not Reported	Must operate within a set annual operational budget and a 5-year capital budget	Not Reported	Not Reported	Not Reported
Saskatoon	Lack of commitment to resources for SWP from federal, provincial, municipal senior government officials	Unwillingness of federal, provincial, municipal governments and First Nations and Métis people and stakeholders to assume financial burden of plan	Not Reported	Lack of communication and financial commitment among multiple levels of government and local people	Not Reported
Halifax	Lack of support from municipal and provincial regulators Lack of regulations to protect water supply	Insufficient long-term funding	Not Reported	Biggest risk: informal recreational activity around water sources, public pressure to make the land	Not Reported

	area; lack of expertise at regulator level			available for recreation	
Toronto	Lack of ability to protect private wells	No compensation Lack of funds to support education programs	Not Reported	Not Reported	Not Reported

CHAPTER 5

5.0 DISCUSSION

The results of this research are discussed in this chapter based on each capacity element into following sections: political capacity, financial capacity, institutional capacity, technical capacity, human resources capacity, and last section discusses general observations related to SWP capacity in metropolitan Canadian areas.

5.1 Political Capacity

All participants in this research strongly appreciate the role of provincial governments to facilitate SWP activities in their watershed. The extent to which political capacity is present to facilitate development of a SWP plan is considered the most significant of the five capacity areas.

According to the results of this study, provincial governments have, since the Walkerton incident, increased their role in protecting municipal drinking water quality in metropolitan Canadian areas. This finding is inconsistent with the results in small communities. For example, de Loë and Kreutzwiser (2005) commented that after Walkerton's contamination, the role of provincial governments to facilitate the Walkerton Inquiry's recommendations remained limited, and he called for provincial government initiatives and support for leadership to simplify and support SWP implementation and regulations at the local level. Additionally, the participants expressed that the requirements of provincial regulations including tools such as the safe drinking water strategies and the requirements of the drinking water acts have played a significant role in conducting effective SWP activities; this is inconsistent with results in Annapolis valley, Nova Scotia where Timmer et al. (2007) argued that provincial legislation is redundant or unwieldy and constrains the local community's ability to practice SWP. They further stressed that SWP regulations should be designed at the local level and local government should pay attention to local capabilities if provincial guidelines are not appropriate for SWP needs.

5.2 Financial Capacity

A stable and long-term budget is important and a primary necessity to facilitate SWP implementation. According to Like and Day (1998), the capacity of agencies, organizations, and citizens to effect watershed management decreases if financial resources are reduced. Watershed management and SWP implementation costs require long-term commitment and support. In the results of this study, similar to other studies in small communities, most participants expressed concern about the need for adequate funding to implement a SWP plan. According to the manager in Halifax, the SWP plan in Halifax has annual funding of about \$300,000 coming from taxes and sewer and water service fees. Moreover, in Victoria, the Water Department has complete

autonomy and the legal authority to protect its water resources. Unfortunately, in both cities, participants indicated that the current funds cannot hope to address the long-term costs to fulfill their water management plans in the future. Furthermore, additional funds to increase local awareness are needed to run public education and outreach programs, especially among small communities and private well owners. Thus, it is clear that municipalities require external resources or funds to address long-term SWP implementation costs.

The findings of this research indicate that political and social support, commitment, and communication at various levels are required to obtain sufficient funds to support the cost of SWP operations and improve current institutional issues. Timmer et al. (2007) noted that “one way to reduce local resistance, costly delays and even litigation is to involve community members as active participants and to use education and communication to build awareness of watershed problems and solutions”. In Saskatoon, there is still a need for strong commitment and cost-sharing from all parties of the local community and all levels of government. Ivey et al. (2006a, 2006b) also considered political and social involvement and support to be critical elements for local SWP capacity. This research highlights the need for political commitment to forge horizontal and vertical linkages to increase local funds that address technical and institutional needs. De Loë et al. (2002) also stated that, in small communities, mitigating the limitations of financial and technical resources can be achieved by making efforts to build community support and establish horizontal and vertical linkages with other organizations and agencies.

5.3 Institutional Capacity

In Canada, the municipal water agency or utility has most of the responsibility to conduct and practice SWP activities based on provincial regulations; local agencies usually have a greater ability to understand the local watershed issues and circumstances than provincial government

agencies. This study is the first study in metropolitan Canadian areas. In the previous studies, in rural areas (de Loë et al., 2002; de Loë & Kreutzwiser, 2005; Patrick et al., 2008; Timmer et al., 2007) the absence of single leadership to manage watershed issues, the fragmentation of watershed responsibility and the relationship among multiple agencies, and limitation of authority to undertake SWP activities were identified as the biggest factors limiting local ability to undertake SWP planning. In contrast, numerous participants expressed the importance of giving authority to source water management and transferring all watershed management responsibilities to one agency as being an essential factor in facilitating the protection of drinking water quality. This finding supports de Loë and Kreutzwiser (2005) “Calls for leadership, strengthened institutional arrangements, enhanced financial and technical resources, and increased citizen involvement and awareness are prominent in numerous recent international reports in global water situation.”

For current and future land use management and to control urban and rural activities, local governments should have the legal authority to undertake SWP (Balco, 1992; Centner et al., 2002; Peckenham et al., 2002). The importance of autonomy over land use decisions in which owning land restricts public access towards watershed management quality is mentioned in this study by the participants in Victoria and Halifax. Patrick et al. (2008) identified the role of institutional power to undertake SWP activities and how the limitation of the authority to control watershed land use influenced and constrained local ability to conduct SWP activities in the Okanagan Valley, BC. Also, Ivey et al. (2006a) found that a non-existing connection between land use planning and water management and the absence of legal authority to restrict land use activities with potential to impact water quality was a severe barrier to SWP in the Oldman River watershed.

5.4 Technical Capacity

As mentioned above, the results of this research show the responses to the Walkerton, Ontario (2000) water contamination event in metropolitan Canadian areas. According to the results, local municipalities, since that time, have increased their efforts to augment their technical capabilities. Technical resources, such as increased availability of water quality data and data regarding human activities and the natural events that cause water quality hazards, exist through monitoring programs and risk assessments. This is consistent with Timmer et al. (2007) statement, “the technical capacity of local governments to protect source water supplies can be demonstrated by the existence of watershed monitoring programs; the ability of easily accessible watershed data”.

Several observations are discussed next. First, communication and partnership with other government agencies and stakeholders is an essential factor in conducting monitoring programs and regular sampling. According to the TRCA in Toronto, monitoring programs have been conducted successfully through partnerships with other government agencies and watershed members. This observation supports de Loë and Kreutzwiser (2005) statement, “Linkages and partnerships can lead to sharing data, equipment, staff, and cost of studies, and can help municipalities overcome key institutional problems”. Also, Ivey et al. (2006b) found the same results, that partnerships with municipalities, consultants, and watershed planners contribute strongly to municipal knowledge that supports SWP. Moreover, education programs and science-based work is recognized in this study by participants as being necessary data viability and an effective monitoring program.

Provincial governments should support local municipalities with new data. According to the two participants from Saskatoon, the provincial government must increase its role to share new data and update the current information for local municipalities to address new water issues and

deal with issues that might lead to altered local water quality such as population growth. This observation explains how it is important for SWP to be a live document and amended to address all new issues that could affect the effectiveness of SWP implementation and performance.

5.5 Human Resources Capacity

Human resources for SWP include the individual knowledge, skills, and abilities held by planners and operators (Mead, 1986; Murray et al., 1995). Unexpectedly, this research we found a lack of personnel and human resources to support SWP implementations in our study. According to the number of participants (nine), the questionnaire required staff with a high-level of knowledge and awareness about the issues that affect developing a SWP plan in their cities. The number of participants was limited in all four case studies, which indicates the need to increase the number of training opportunities.

Moreover, during the study, some members apologized because they did not have sufficient knowledge to complete the questionnaire. The Halifax Utility recently recognized the importance of training and experts for SWP has increased the number of utility operators. According to the manager in Halifax, the number of training staff has increased at the provincial and local level; this case suggests that other cities increase the number of training staff and the need to communicate with external experts to provide recommendations for improving local technical capabilities for SWP needs. This suggestion is consistent with the Timmer et al. (2007) finding, “the combination of provincial and private expertise in SWP and watershed planning provides a significant human resources pool to assist municipalities with SWP activities”

5.6 SWP Capacity in Metropolitan Canadian Areas, General Facts

Our findings for local capacity of SWP is consistent with other studies in small communities (de Loë et al., 2002; de Loë & Kreutzwiser, 2005; Ivey et al., 2006a, 2006b; Timmer

et al., 2007). The findings show that local SWP capacity is complex and cannot be built by a single capacity element. In many cases, challenges to meet factors of capacity lead to numerous gaps of local capacity; for example, political capacity and legal authority to design necessary SWP regulations is the most important factor influencing the ability of personnel to conduct technical studies and institutional arrangements. The lack of authority to improve regulations and bylaws to protect private wells in Toronto has resulted in an absence of many necessary regulations and other technical activities such as periodic monitoring and risk assessment. Also, Halifax participants have concerns regarding the areas where the municipality has no legal authority. In both Toronto and Halifax, participant call for provincial regulations to support the creation of SWP bylaws to make better land uses decision indicate their trust of provincial bylaws and regulations as effective guides that support their responsibility in SWP and land uses decisions. Finally, meaningful communication and cooperation among governments, organizations, agencies, stakeholders, and local citizens is critical for SWP planning activities.

Generally, the needs and tools to build local SWP capacity in metropolitan Canada seem to be consistent with the needs in non-metropolitan Canada. Local SWP capacity in metropolitan Canadian areas is strengthened and enhanced by provincial regulations and tools and by strong, unified local leadership to undertake SWP performance.

CHAPTER 6

6.0 CONCLUSION

This chapter contains three sections: the research significance of the findings follow up several recommendations, the contribution of this research to academic literature, and the final section will highlight the limitations of the research, including suggestions for future research.

6.1 Significance of Finding

Synthesis of information from questionnaires and document reviews was used to identify factors that facilitate and constrain developing a SWP plan in the metropolitan Canada. Four Canadian cities were chosen as case studies based on their geographic distribution within Canada. The results in each city were grouped under the themes of facilitating and constraining factors. Under each of these two themes, the results were analysed based on five common forms of capacity taken from the water resource literature: political, financial, technical, institutional, and human resource capacity. Based on the results, political capacity was the most significant capacity-related factor to influence SWP uptake. Political capacity includes provincial regulations and initiatives, legal authority through landownership to protect water quality, local control over land use activities, and local leadership with responsibility to conduct SWP implementation and other water management procedures. In addition, technical capacity was the second most significant capacity-related factor identified in the research. Technical factors include commitment to, and communication of, provincial and municipal monitoring programs, data collection through risk assessment to inventory human activities, natural cases of water quality contaminations, and cooperation with scientific and research groups to collect data and information for monitoring programs. Institutional capacity, especially in small and rural communities, is not strongly present in the literature. There exists a limitation of legal authority to design a SWP plan in rural areas due to lack of legal authority. This remains a common problem for metropolitan areas where the source watershed area is not under the ownership of the metropolitan region.

Moreover, the results highlight and demonstrate numerous watershed management tools that can be used to protect drinking water supplies in metropolitan Canadian areas, such as provincial regulations and acts, provincial drinking water strategies, education and outreach

programs, and land acquisition. However, the results indicated that there is no single framework for a SWP plan or a single solution that can fit with any watershed issues. A SWP plan can be achieved by many ways and with many tools. Many factors can influence local SWP strategies and the ability to use watershed protection tools, such as the scale or size of watershed and the availability of financial resources. Local municipalities in metropolitan areas should have the responsibility to recognize the effective tools that can fit with local issues and their financial, technical, or institutional capacity.

Several recommendations are provided in the following section in order to improve the current local SWP capacity needs in metropolitan Canada.

Recommendation 1: Provincial governments should support education programs especially in small communities.

The public should understand the impact of their land use activities on water quality, their roles in the SWP process, and how and why their roles can affect decision making. Education and outreach programs can increase public awareness and change local community behavior to reduce risks at the sources of drinking water supplies. Also, educating the communities of people who live near water supply areas will help them comply with municipal regulations and bylaws that aim to control land use activities and enhance sharing of responsibility for the protection of water sources.

Recommendation 2: Commitment for financial support is needed from municipal and provincial governments.

Financial capacity affects other elements for SWP because a lack of financial resources leads to many challenges regarding implementation of SWP activities, including a lack of technical

activities or training opportunities. Local municipalities and watershed utilities should expand their roles to involve all affected groups from local communities with provincial and local government's members to obtain sufficient funds that can be used to support structural and non-structural watershed protection tools and improve the current watershed management activities. This recommendation requires local municipalities or watershed utilities to organize regular meetings and workshops to discuss local watershed needs, how effective SWP processes should be accomplished, and the annual amount of funds needed to protect local drinking water quality and reduce the risks to local community health.

Recommendation 3: Municipalities and watershed utilities should expand their roles to forge horizontal and vertical linkages to increase the opportunity for additional funds.

The local capacity for SWP planning is enhanced and improved when local leadership can support communication and forge linkages among stakeholders and with provincial government agencies. Formal and informal communication and partnerships with other local and government agencies and organizations can reduce many issues in local SWP capacity. For example, some of the cost of monitoring programs for data availability can be reduced through partnerships with watershed organizations. Also, communication with provincial agencies for expert consultation can reduce the need to hire specialists and expertise at a high cost.

Recommendation 4: The SWP plan should be amended and updated.

This recommendation will ensure that the SWP plan is current, including data on any change in watershed conditions. The SWP plan should be amended to provide data that reflect local watershed issues and determine the SWP priorities. In order to achieve an effective SWP plan, this recommendation suggests that the SWP plan should be evaluated and amended

approximately every five years to include all new data that might affect protection of water supplies, such as population increases.

Recommendation 5: Additional training opportunities are needed for municipalities and utilities.

The study indicated the need to increase the number of training opportunities for hydrological, geological, and watershed planning members to help improve general technical studies and data availability. This recommendation suggests external expertise and consultations with either federal or provincial government agencies will fill the gaps in local needs and increase the local capacities to protect drinking water supplies in metropolitan areas.

6.2 Academic Contributions

The results of this study contribute to the academic body of literature by building upon our understanding of local capacity needs for SWP implementation in metropolitan Canada. Past studies and research on this topic focus mainly on rural and agriculture areas. The results of this study indicate that the most important factor to implement SWP is to involve both provincial

regulations as SWP implementations guidance with a local lead agency. Legal authority to control land use activities through owning land can support and fulfill the goal of SWP planning. Communication and partnership work are fundamental methods to improve provincial, financial, technical, and institutional capacities. The results also address several needs for local capacity; provincial government regulations and initiatives should be created in order to protect sources of water from contamination in private wells and small communities. Additionally, funding support is needed to support long-term plan implementation. Training, educational opportunities, and expert knowledge are needed to increase local initiatives in support of SWP activities. The results also indicate that a SWP plan must be a living document, continuously reviewed to ensure the plan is both adaptive and effective. The SWP plan should also include current issues that need to be taken into consideration for the SWP planning process.

6.3 Research Limitations and Future Research

This research included only nine participants. The participants based their knowledge of SWP planning and water management on factors that influenced their involvement in SWP planning. However, participant responses indicated that these participants have the same points of view about the factors that support and constrain SWP planning in their cities. More participants from the environmental, agriculture, and industrial fields could be added in order to include more opinions in order to gain different points of view.

The questionnaire method was chosen to collect data from participants instead of interviews that would have increased geographical challenges of participants living in different Canadian cities. However, in this research, more information and details could be included from

interviews of approximately one hour with each participant. In addition, more questions could be added to the questionnaire for better clarification and information regarding each capacity factor.

This research selected four Canadian cities to investigate opportunities and challenges to develop a SWP plan in metropolitan Canada. A suggestion for future research is to conduct comparative research between two provinces in order to evaluate which provincial regulations best support SWP planning and implementation

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Appendix A: Questioner Questions

1- What is your job title?

- 2- What is your role in water management or water planning in your city?
- 3- What is the main risk to raw (source water) water quality in your city?
- 4- Is a source water protection plan required of your water system by city or provincial law?
- 5- Does your water system include a source water protection plan? If **YES** go to part A, if **NO** go to part B

Part A:

- 5-When was the source water protection plan adopted?
- 6- List and describe the most important factors that facilitated the development of your source water protection plan (e.g. Financial, political, technical, social, others).
- 7- List and describe the most important factors that constrained the development of your source water protection plan (e.g. political, legal, financial, etc.
- 8- Is your source water protection plan being implemented?
- 9- Provide a few examples implementation actions from your source water protection plan.
- 10-Are there any issues that restrict the implementation of your source water protection plan? Describe them.
- 11- What main issues should be addressed in order to improve your source water protection plan?

Part B: if your water system does not have a source water protection plan

- 6- Does your city plan to develop a source water protection plan in the future? Yes or No
- 7- When does your city plan to develop a source water protection plan?
- 8- In your opinion, list and describe the major challenges to developing a source water protection plan in your city/region (financial, political, institutional, etc.
- 9- In your opinion, what is needed to help facilitate a source water protection plan in your city
- 10- In your opinion, is a source water protection plan needed for your city/regional water service?